DES NOT CIRCULATE

Vol. 8 No. 3 JULY, 1954

BRITISH JOURNAL OF PREVENTIVE & SOCIAL MEDICINE

UNIVERSITY OF MICHIGAN
SEP 24 1954
MEDICAL

EDITED BY

LANCELOT HOGBEN, THOMAS McKEOWN, and IAN TAYLOR

WITH THE ASSISTANCE OF

W. MELVILLE ARNOTT, *Internal Medicine*
DUGALD BAIRD, *Obstetrics and Gynaecology*
C. FRASER BROCKINGTON, *Public Health*
F. A. E. CREW, *Social Medicine*
G. P. CROWDEN, *Applied Physiology*
GUNNAR DAHLBERG, *Medical Statistics*
R. W. B. ELLIS, *Paediatrics and Child Health*
J. R. MARRACK, *Nutrition*
J. A. FRASER ROBERTS, *Human Genetics*
ALICE M. STEWART, *Social Medicine*
and the EDITOR of the *British Medical Journal*

CONTENTS

PAGE

A Study of Two Years' Work in Northern Ireland General Practice. J. C. C. CRAWFORD 81

Recent Trends in Survival of Patients with Respiratory Tuberculosis. C. R. LOWE.. 91

Body-Weight of Men related to Stature, Age, and Social Status. E. M. B. CLEMENTS and KATHLEEN G. PICKETT 99

Chest Girth of Men related to Stature, Age, Body-Weight, and Social Status. E. M. B. CLEMENTS and KATHLEEN G. PICKETT 108

Heterospecific Pregnancy. J. M. JOHNSTONE 117

Sex Ratio and the ABO Blood Group System. J. M. JOHNSTONE 124

Social Class Variations in Mortality. W. P. D. LOGAN 128

LONDON

BRITISH MEDICAL ASSOCIATION

TAVISTOCK SQUARE, W.C.1

YEARLY SUBSCRIPTION (4 NUMBERS) £2 2s. 0d. U.S.A. $7.00 SINGLE NUMBER 12s. 6d.

NOTICE TO CONTRIBUTORS

THE BRITISH JOURNAL OF PREVENTIVE AND SOCIAL MEDICINE is intended for the publication of original work in the field. Contributions in the English language from workers of any nationality may be considered for publication.

As understood by those who are responsible for this Journal, social medicine is that branch of science which is concerned with: (*a*) biological needs, interactions, disabilities, and potentialities of human beings living in social aggregates; (*b*) numerical, structural, and functional changes of human populations in their biological and medical aspects. To a large extent its methods must necessarily be statistical, involving the use of numerical data obtained either from official sources or from special field investigations, and interpreted in the light of established findings of the laboratory and of the clinic. Social medicine takes within its province the study of all environmental agencies, living and non-living, relevant to health and efficiency, also fertility and population genetics, norms and ranges of variation with respect to individual differences, and investigations directed to the assessment of a regimen of positive health.

All papers submitted for publication and all other editorial matters should be addressed to The Editors, BRITISH JOURNAL OF PREVENTIVE AND SOCIAL MEDICINE, c/o British Medical Association, Tavistock Square, London, W.C.1.

Papers are accepted on the understanding that they are subject to editorial revision, and that they are contributed to this Journal only. The Editors cannot undertake correspondence about papers returned as unsuitable on the advice of members of the Editorial Board.

Adequate reference should be made to previous work on the subject of the paper. A summary of observations and conclusions must be given.

Papers sent for publication must be typewritten on one side of the paper only, with double spacing and with a margin of at least 1¼ inches. Illustrations should be used sparingly. Photographs should be printed on glossy paper and should be a little larger than the size desired for reproduction. Drawings and diagrams should be done in black ink on tracing linen, Bristol board, or stout, white paper. Any lettering on these drawings should be lightly inserted in pencil. The setting up of type by the printers will be much facilitated if attention is paid to the proportions of the standard page measurements. The Editors express the hope that contributors will study the conventions of shading and design of charts employed in the Journal with a view to standardizing visual symbols for ready recognition.

References should be arranged alphabetically at the end of the paper according to the Harvard system. If the reference is to a book, the place of publication, the number of the edition, and the page number should be given. In the text the year of publication must follow the author's name, more than one paper in any one year being indicated by a small letter (a, b, c) after the date. The reference should be given as follows: author's name, initials, year of publication (in parentheses), title of periodical (in italics, abbreviated according to the *World List of Scientific Periodicals*), volume number (bold type arabic numerals), and first page number (ordinary type arabic numerals); book titles (in roman and inverted commas), followed by publisher, place of publication, etc.:

Engle, E. T., and Shelesnyak, M. C. (1934). *Hum. Biol.*, **6**, 431.
Fluhmann, C. F. (1936). *Amer. J. Obstet. Gynec.*, **31**, 573.
—— (1939). " Menstrual Disorders." W. B. Saunders, Philadelphia.
Gómez, F. D. (1942). *Hoja tisiol.*, **2**, 25.

Contributors will receive one proof, but it is assumed that all but verbal corrections will have been made in the original manuscript; an allowance at the rate of ten shillings per sheet of sixteen pages is made for alterations in the proof (printer's errors excepted), and contributors will be responsible for any excess.

Twenty-five reprints of papers will, if desired, be provided free. A limited number of additional reprints at cost price can be supplied if application is made when returning proofs. An estimate of the cost will be given on application to the Publishing Manager, British Medical Association.

The Journal will be published quarterly.

Papers which have appeared in THE BRITISH JOURNAL OF PREVENTIVE AND SOCIAL MEDICINE remain the property of the Journal, and permission to republish them must be obtained from the Editors.

Applications for advertisement space should be addressed to the Advertisement Manager, British Medical Association, Tavistock Square, London, W.C.1.

NOTICE TO SUBSCRIBERS

Subscriptions (£2 2s. 0d. per annum) are payable to the British Medical Association.

Brit. J. prev. soc. Med. (1954), **8**, 81–90

A STUDY OF TWO YEARS' WORK IN NORTHERN IRELAND GENERAL PRACTICE

BY

J. C. C. CRAWFORD

Belfast

Introduction

When it is appreciated that it is to the general practitioner that almost all sick people turn for medical attention or advice, and that it is through his hands that they first pass, it is perhaps surprising that until the last few years so few contributions to the study of morbidity have been made by family doctors. The pioneer work of McGregor (1949, 1950, 1953) and Fry (1952) among others broke the ground in this field, but the feeling grew that a wider picture, covering different types of general practice, would contribute more to the understanding of the subject than would single practice studies. Accordingly the General Register Office has published a preliminary analysis of records from eight general practices (Logan, 1953) and the College of General Practitioners is planning an investigation on similar lines. Nevertheless, there is still a place for individual studies in this field. There is, for example, greater uniformity in applying medical terms to the different morbid conditions encountered, when diagnosis is the work of one practitioner. Logan (1953) has instanced the common disparities between his practitioners in this respect. The following account of work in my practice during two separate periods each of one year (from November 1951 to October 1952, and November 1952 to October 1953) may therefore be of value in contrasting two years of study and for comparison with other single practice reports such as those mentioned above, and that reported by Backett, Shaw, and Evans (1953) and Backett, Heady, and Evans (1954).

Description of Practice

The practice is a suburban one in the south of Belfast, an industrial county borough with a population of 443,671 at the 1951 census. The majority of the patients can be described as "middle class"; no particular occupational or industrial group predominates. The area of the practice is limited to about 4 square miles and involves an annual car mileage of about 8,000 miles. The practice is run single-handed with the non-professional assistance of a part-time secretary-receptionist and adequate domestic help. There is a loose arrangement as regards "off duty" work with a neighbouring practitioner, who at one time was an assistant in my practice, and who has the same outlook on general practice. At holiday times he has preserved the continuity of the records used in the present survey. Each of our houses has a telephone extension to the other so that frequent contact and exchange of thought is encouraged.

The practice is fortified by ample hospital and laboratory services and both out-patient and in-patient facilities are frequently used. As in most urban areas, no hospital beds are available for the general practitioner, and although he is welcome to visit his patients he has no share in their treatment while they are in hospital. Pay clinics and private nursing homes are available for patients who wish to pay for their treatment; the nursing homes are becoming steadily fewer, but it appears that the clinics, attached as they are to the hospitals and with better diagnostic facilities, are as busy as ever they were.

The working day in the practice starts at 9 a.m.; the morning is devoted to visits to patients; between 2 and 4 p.m. patients are seen at the surgery; private patients can be seen by appointment between 2 and 3 p.m. Between 4 and 6 p.m. further visits are made to patients' homes. The evening surgery usually lasts till about 8 p.m. Thereafter the day is free, apart from emergency calls and night visits, fortunately rarer, in this practice, than the public imagines. Life assurance examinations and other special consultations are fitted into the day by arrangement.

The pressure of work varies considerably. In the summer and early autumn there is enough free time

to enable the doctor to catch up on the medical reading which has largely to be postponed at other seasons.

Composition of Practice

The potential patients of the practice can be classified into three groups:

(1) About 1,400 registered under the National Health Service.

(2) About 200 private patients, requiring often extra and perhaps disproportionate attention, and some at least coming privately at one time, and at another attending their own "panel" doctor.

(3) A large body of students at a Training College, of a narrow age group, who are given service only during college terms.

Groups 2 and 3 have been omitted from the present survey in view of the special circumstances involved.

Table I shows the variations in Group 1 during each of the 2 years under review. In this and subsequent tables "Year 1" refers to 1951–52 and "Year 2" to 1952–53, each year beginning on November 1. Of the 1,488 patients on the register at the beginning of the first year, 1,384 remained on the register throughout that year. For the second year the comparable figures were 1,450 and 1,341. It was considered more satisfactory to analyse the experience of only those patients who were on the list for the complete 12 months of each period of study. Their age and sex distributions are shown in the last two columns of Table I, and it will be seen that in each year they do not differ materially from those of the average populations exposed to risk. Moreover this procedure permits compilation of precise frequency distributions of sickness events which are of considerable value in these studies.

For some purposes, *e.g.* consideration of births and deaths, it has been necessary to talk in terms of the complete register, but where this is done it is specifically stated, and in the absence of such statements all the comments which follow refer to the experience of the 1,384 patients who were with the practice throughout the whole year of 1951–52 and the corresponding group of 1,341 for 1952–53.

Recording System

Medical attention given to patients was classified according to the International Statistical Classification of Diseases, Injuries, and Causes of Death (World Health Organization, 1948). Each attendance of a patient at the surgery and each visit to the home of a patient was recorded. In the Tables and discussion which follows these are referred to as "surgery attendances" and "home visits" respectively. Continuous attention, that is, a series of connected surgery attendances and/or home visits is described as a "spell of medical attention". In most instances a spell can be regarded as a complete illness but some caution is needed in so interpreting it; for example inoculations and most obstetric work cannot be so described.

A record card was available for each patient on the register, showing name, age, sex, and address. Each card was ruled horizontally to give a line for each month of the year and had a number of columns which were allotted to diagnostic entities as they arose. In the cells of the grid so formed entries were made to show the number of surgery attendances and home visits each month for each classified diagnosis. The information was entered on the cards by extracting the relevant information from the medical records maintained in the routine administration of the practice.

Separate records were kept of referrals of patients to hospital externs and consultants and of admissions to hospitals and pay clinics, distinguishing the various specialist services involved.

Thus a number of activities associated with general practice are omitted from this study. No mention has been made of special examinations for life assurance, emigration, or special employment, requests for "a check up", or the demands of temporary Health Service patients. Similarly no record has been made of certifications and of requests for prescriptions to be repeated, nor was it possible to assess telephone conversations in which medical advice was given. If no other medical attention was involved these small services have been ignored.

Available Data

Thus for each patient on the register the following information is available for analysis for each year:

(1) Age and sex.

(2) Number of surgery attendances made each month classified by diagnosis.

(3) Number of home visits made each month classified by diagnosis.

(4) Number of separate spells of medical attention classified by diagnosis.

(5) Number of referrals to a hospital extern, classified by type of clinic.

(6) Number of referrals to a consultant, classified by specialist service involved and whether seen in own home or specialist's consulting room.

(7) Number of admissions to hospitals, classified by hospital department.

(8) Number of admissions to a pay clinic, classified by type of admission.

The possible combinations of these eight items for any group of patients into various types of index or rate are of course numerous. I have, therefore, selected those combinations which appear to be of particular interest and presented statistics for the age and sex groups shown in the Tables. In the present analysis no attempt has been made to consider the month to month, or seasonal variations (Items 2–4 above are available in monthly periods); it has been preferred to postpone such analysis and to deal with it separately.

Population at Risk

The age and sex distribution of the patients studied is shown in the last two columns of Table I. The age and sex distribution of the 1,384 patients studied in 1951–52 is very similar to that of the 1,341 in 1952–53. In each period there were more males than females under the age of 15, but at later ages women out-numbered men, as they did for all ages combined.

TABLE I

COMPOSITION OF REGISTER FOR THE YEARS 1951–52 AND 1952–53

Age Group (yrs)		Average Number of Patients during Year*		Number of Patients on Register for Whole Year*	
		Year 1	Year 2	Year 1	Year 2
Male	0–	48·5	44·0	43	40
	5–	97·5	102·5	93	98
	15–	182·5	167·5	171	157
	40–	168·0	163·5	164	157
	60+	117·0	116·0	112	111
	Total	613·5	593·5	583	563
Female	0–	41·5	32·5	35	29
	5–	91·5	88·0	87	86
	15–	272·0	252·5	247	228
	40–	256·0	262·0	245	251
	60+	194·5	191·5	187	184
	Total	855·5	826·5	801	778

* In this and subsequent Tables "Year 1" refers to the year 1951–52 "Year 2" refers to the year 1952–53.

Of the 1951–2 practice population, 5·6 per cent. were of pre-school age, and 13·0 per cent. of school age; in the age groups 15–39, 40–59, and 60 and over, the percentages were 30·2, 29·6, and 21·6. The comparable percentages for the second year were 5·1, 13·7, 28·7, 30·4, and 22·0.

If for the moment private patients in this second year are considered, taking only those that can be described as settled (as against those coming occasionally as private patients), there are only nine males under 60 years old as against 34 aged 60 and over; among females there are 22 under 60 years old and eighty aged 60 and over. This underlines how largely private practice has now become the care of the elderly. Indeed, if the private patients are added to those on the register, the proportion aged 60 and over becomes 27·5 per cent., a truly remarkable figure for any practice. This may be compared with 13·8 per cent. for the same age group in the Northern Ireland population as a whole.

Work Done

The accompanying Tables give an impression of the work done in practice during the 2 years and provide figures for comparison between them. In general the 2 years presented remarkably similar pictures. Both years were fairly average ones, without major epidemics. (It may be pointed out, however, that attendance on patients excluded from the investigation as described earlier, as well as insurance and other work, probably occupied nearly as much time as that devoted to the population under consideration.)

Table II shows the average number of surgery attendances, and/or home visits per patient on the register in each of the 2 years under study for each age and sex group. Altogether there were 2,404 surgery attendances and 1,919 home visits in the first year, and 2,298 and 2,074 respectively in the second year. The average number of home visits and surgery attendances over the whole period was 3·19 per patient on the register and varied between about two and five per patient in the tabulated age and sex groups. In three age groups females demanded more attention on the average than males in the first year, but this was true of only one age group in the second year, thus these data give no support to a consistent sex difference. It should be noted, however, that male averages were greater in both years among school children and amongst persons aged 60 and over. This Table demonstrates the well recognized fact that the heaviest work in general practice is in connection with the very young and the old, the 15–39 years age group in both years and both sexes demanding least of all.

TABLE II

AVERAGE NUMBER OF SURGERY ATTENDANCES AND/OR HOME VISITS PER PATIENT ON REGISTER DURING THE YEARS 1951–52 AND 1952–53

Age Group (yrs)		Average Number of Surgery Attendances and/or Home Visits per Patient on Register		Surgery Attendances as Percentage of Total	
		Year 1	Year 2	Year 1	Year 2
Male	0–	4·12	4·28	49·7	39·2
	5–	3·40	4·35	42·7	34·5
	15–	1·95	2·34	73·6	73·3
	40–	2·26	2·39	64·3	61·4
	60+	4·75	4·65	40·4	42·4
	Total	2·96	3·30	53·3	50·3
Female	0–	4·57	3·48	31·3	38·6
	5–	3·22	3·67	45·7	37·3
	15–	2·52	2·29	71·7	78·4
	40–	2·98	2·92	62·6	67·5
	60+	4·29	4·59	50·1	36·1
	Total	3·24	3·23	57·1	54·3

A study of the ratio of surgery attendances to home visits shows in both years and in both sexes a relatively high proportion of home visits up to the age of 15. From that age up to 60 years the proportion of visits is relatively low, and it then increases

again after that age. Thus not only was the total volume of attention greater at the extreme ages, but also the type of attention was different, in that it included more visits to the patients' homes.

Table III shows the cumulative percentage distribution of patients by number of surgery attendances and home visits combined during each of the 2 years of study. Thus in the first year only 9·3 per cent. of all boys under 5 were not seen at all, 30·2 per cent. were seen not more than once, 44·2 per cent. not more than twice, and so on. Incidentally, in the second year only one boy under 5 did not require medical attention. On the whole, however, the figures for the 2 years are very similar. It will be noted that 35·7 per cent. of the males during the first year and 35·0 per cent. during the second did not ask for my services. Among the females the figures are not quite so similar, being 36·1 and 32·4 per cent. respectively. In each age group and in both sexes the percentage who were not seen at all increased up to the age of 60. After that age, as might be expected, the percentage again became smaller, though not at all strikingly in the second year among females.

Table IV shows the number of spells of medical attention, as opposed to the amount of work done expressed as surgery attendances and/or home visits. Thus in the first year the 43 males in the 0–4 yrs age group had 115 spells of medical attention

TABLE IV

SPELLS OF MEDICAL ATTENTION DURING THE YEARS 1951–52 and 1952–53

Age Group (yrs)		Spells of Medical Attention			
		Year 1		Year 2	
		Total No.	No. per Patient on Register	Total No.	No. per Patient on Register
Male	0–	115	2·67	117	2·93
	5–	200	2·15	241	2·46
	15–	181	1·06	190	1·21
	40–	173	1·05	155	0·99
	60+	170	1·52	153	1·38
	Total	839	1·44	856	1·52
Female	0–	89	2·54	67	2·31
	5–	160	1·84	180	2·09
	15–	338	1·37	332	1·46
	40–	348	1·42	353	1·41
	60+	293	1·57	264	1·43
	Total	1,228	1·53	1,196	1·54

TABLE III

CUMULATIVE PERCENTAGE DISTRIBUTION OF PATIENTS BY NUMBER OF SURGERY ATTENDANCES AND/OR HOME VISITS MADE DURING THE YEARS 1951–52 AND 1952–53

Age Group (yrs)		Year	Number of Surgery Attendances and/or Home Visits					Total	
			0	1 or less	2 or less	3 or less	4 or less	%	Nos. on which Percentages are Based
Males	0–	1	9·3	30·2	44·2	55·8	67·4	100	43
		2	2·5	7·5	15·0	35·0	67·5	100	40
	5–	1	18·3	35·5	49·5	63·4	73·1	100	93
		2	21·4	33·7	40·8	50·0	58·2	100	98
	15–	1	43·9	63·7	76·0	83·0	86·0	100	171
		2	40·8	57·3	70·1	78·3	83·4	100	157
	40–	1	48·8	65·2	75·0	81·1	84·8	100	164
		2	43·9	61·1	73·9	82·2	86·0	100	157
	60+	1	28·6	45·5	54·5	67·9	73·2	100	112
		2	37·8	50·5	62·2	68·5	71·2	100	111
	Total	1	35·7	53·7	65·0	74·4	79·8	100	583
		2	35·0	49·4	60·6	69·4	76·2	100	563
Females	0–	1	11·4	28·6	48·6	51·4	54·3	100	35
		2	13·8	20·7	41·4	55·2	69·0	100	29
	5–	1	25·3	34·5	52·9	63·2	74·7	100	87
		2	24·4	37·2	51·2	65·1	68·6	100	86
	15–	1	38·5	55·1	70·0	78·5	83·4	100	247
		2	32·9	52·6	63·6	72·8	82·9	100	228
	40–	1	40·4	57·1	68·2	75·1	80·4	100	245
		2	35·1	55·0	64·9	71·7	78·9	100	251
	60+	1	36·9	49·7	57·8	66·8	74·9	100	187
		2	34·8	50·0	56·5	63·0	70·1	100	184
	Total	1	36·1	51·1	63·8	71·9	78·3	100	801
		2	32·4	49·9	60·2	68·6	76·5	100	778

or 2·67 spells per patient. It will be noticed that the average number of spells per patient was relatively high up to 15 years, after which it steadily decreased with each age group up to 60 years. There was then a definite rise, less marked in the females. Comparison of the 2 years shows an increase in the second year in the number of spells per patient under 40 years of age, and a decrease in later age groups, the total average number of spells per patient being very similar in the 2 years.

Table V contrasts the surgery attendances and home visits per spell of medical attention, and allows a number of comparisons to be made. The totals for combined surgery attendances and visits in the 2 years, and for each sex, are remarkably similar, and though there is variation between the years in the different age groups no consistent pattern is apparent. In total the average number of visits and/or attendances per spell was just over two and varied from about 1·5 among children to about three or more in the oldest age group. Generally there was a fairly steady rise in the number of combined attendances and home visits per spell of medical attention as age advanced. In both years home visits predominated up to age 15, but from then until age 60 surgery attendances exceeded home visits in each spell of medical attention. After age 60 the tendency of old people to need relatively more home attention is again shown. Naturally old people are often unable to come to the surgery even for conditions which are not serious in themselves, and many old people receive real encouragement from periodic visits from the doctor, quite apart from the treatment of any specific illness, and the frequent small discomforts of old age can then be discussed.

TABLE V

AVERAGE NUMBER OF SURGERY ATTENDANCES AND/OR HOME VISITS PER SPELL OF MEDICAL ATTENTION DURING THE YEARS 1951–52 AND 1952–53

Age Group (yrs)		Average Number of Surgery Attendances and/or Home Visits per Spell of Medical Attention					
		Surgery Attendances		Home Visits		Total	
		Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Male	0–	0·77	0·57	0·77	0·89	1·54	1·46
	5–	0·68	0·61	0·91	1·16	1·58	1·77
	15–	1·35	1·42	0·49	0·52	1·84	1·93
	40–	1·38	1·49	0·76	0·94	2·14	2·43
	60+	1·26	1·43	1·86	1·94	3·13	3·37
	Total	1·10	1·09	0·97	1·08	2·06	2·17
Female	0–	0·56	0·58	1·24	0·93	1·80	1·51
	5–	0·80	0·66	0·95	1·10	1·75	1·76
	15–	1·32	1·23	0·52	0·34	1·84	1·57
	40–	1·31	1·40	0·78	0·67	2·10	2·07
	60+	1·37	1·16	1·37	2·05	2·74	3·20
	Total	1·21	1·14	0·91	0·96	2·11	2·10

MORBIDITY

In Table VI (overleaf) the spells of medical attention have been classified by age and sex of patient and diagnosis. The indices shown are the average number of spells of medical attention per patient on the register in each year, and it will be appreciated that in some instances these averages are based on rather small numbers (see the totals in Table IV). Consequently one can do no more here than comment on the consistent trends which emerge from a study of Table VI.

The composition of the nineteen diagnostic groups used is apparent from the International List numbers, but it is necessary to describe the contents of some groups in so far as this practice is concerned. Tuberculosis forms a very small part of the infectious diseases group; no new cases were detected in either year; in the first year four old patients were attended, but none was seen in the second year. Among mental conditions psycho-neurosis predominated. Cardiovascular disease included such disorders as chilblains, varicose veins, and haemorrhoids. Among skin diseases were classed subcutaneous infections, such as cellulitis and whitlows, but allergic skin disorders were included among the allergies. Ill-defined conditions comprised the tired and the run-down, and questions of old age and infant management.

For all ages combined for both years and both sexes, the highest average number of spells was attributed to diseases of the respiratory tract including influenza. This diagnosis accounted for about 25 per cent. of all spells of sickness experienced by males and for about 20 per cent. of those experienced by females. The average number of spells per patient in the first year was 0·32 for males and 0·26 for females, and in the second year 0·43 and 0·34 per cent. respectively; no other diagnostic group exceeded a level of 0·16 spells per patient.

In the pre-school age group, 0–4 years, respiratory diseases again gave the maximum average number of spells per patient in each year and for each sex. The averages were 0·88 for males and 0·66 for females in the first year and 0·80 and 0·83 in the second year. This represented about 25 to 35 per cent. of all spells of sickness experienced in this age group. Infectious diseases, allergic disorders, and diseases of the alimentary tract also ranked fairly high in this age group.

TABLE VI

AVERAGE NUMBER OF SPELLS OF MEDICAL ATTENTION PER PATIENT ON REGISTER, BY DIAGNOSIS DURING THE YEARS 1951–52 AND 1952–53

International Classification Numbers	Diagnosis	Year	Male						Female					
			Age Group (yrs)						Age Group (yrs)					
			0–	5–	15–	40–	60+	Total	0–	5–	15–	40–	60+	Total
001–138	Infectious diseases, including tuberculosis	1	0·21	0·38	0·05	0·03	0·01	0·10	0·43	0·31	0·06	0·02	—	0·07
		2	0·43	0·42	0·03	0·01	0·01	0·11	0·31	0·29	0·04	0·02	0·02	0·07
140–239	Tumours	1	0·02	—	0·01	0·01	0·01	0·01	—	—	0·004	—	0·01	0·002
		2	—	—	—	0·01	0·01	0·01	—	0·01	0·02	0·02	—	0·01
240–245	Allergic disorders	1	0·30	0·15	0·05	0·02	0·03	0·07	0·20	0·09	0·05	0·05	0·04	0·06
		2	0·23	0·07	0·04	0·03	0·03	0·05	0·17	0·12	0·04	0·04	0·02	0·05
250–289	Endocrine disorders, with obesity	1	—	0·01	0·02	0·02	0·03	0·02	—	—	0·02	0·05	0·03	0·03
		2	0·03	—	0·01	0·03	0·01	0·01	0·03	0·03	0·03	0·03	0·02	0·03
290–299	Anaemias	1	0·02	0·02	0·01	—	0·01	0·01	0·06	0·01	0·01	0·01	0·03	0·02
		2	—	—	—	—	—	—	—	—	—	0·004	0·02	0·01
300–326	Mental conditions	1	0·07	0·09	0·05	0·09	0·04	0·07	—	0·03	0·11	0·09	0·10	0·09
		2	0·05	0·09	0·04	0·09	0·05	0·07	0·03	0·05	0·10	0·14	0·07	0·10
330–369	Diseases of central nervous system	1	—	0·01	0·01	0·01	0·09	0·02	—	—	0·02	0·02	0·05	0·02
		2	—	—	0·02	0·01	0·05	0·02	—	—	0·02	0·01	0·03	0·02
370–389	Diseases of eye	1	0·05	0·05	0·05	0·04	0·03	0·04	0·09	0·08	0·09	0·05	0·06	0·07
		2	0·15	0·06	0·06	0·01	0·03	0·05	0·07	0·10	0·04	0·05	0·11	0·07
390–398	Diseases of ear	1	0·14	0·12	0·06	0·08	0·11	0·09	0·23	0·09	0·06	0·07	0·05	0·07
		2	0·30	0·15	0·09	0·05	0·14	0·12	0·10	0·15	0·07	0·09	0·07	0·09
400–468	Cardiovascular diseases	1	0·05	0·01	0·02	0·07	0·18	0·07	—	0·01	0·06	0·09	0·26	0·11
		2	—	—	0·02	0·07	0·23	0·07	—	—	0·06	0·08	0·21	0·09
470–527	Diseases of respiratory tract, with influenza	1	0·88	0·55	0·20	0·18	0·30	0·32	0·66	0·57	0·22	0·22	0·13	0·26
		2	0·80	1·00	0·31	0·20	0·27	0·43	0·83	0·70	0·33	0·25	0·22	0·34
530–587	Diseases of alimentary tract, with hernia	1	0·26	0·22	0·08	0·08	0·14	0·13	0·20	0·07	0·07	0·09	0·18	0·11
		2	0·20	0·14	0·10	0·06	0·14	0·11	0·17	0·10	0·11	0·07	0·09	0·09
590–617	Urinary infections and diseases of male genital organs	1	0·12	0·01	0·02	0·02	0·08	0·04	—	0·05	0·02	0·02	0·04	0·02
		2	0·08	0·01	0·01	0·01	0·06	0·02	0·03	—	0·004	0·03	0·04	0·02
620–689	Diseases of female genital organs, with deliveries	1	—	—	—	—	—	—	—	—	0·15	0·13	0·04	0·09
		2	—	—	—	—	—	—	—	0·01	0·15	0·08	0·04	0·08
690–716	Skin diseases, including infections	1	0·07	0·13	0·14	0·11	0·13	0·12	—	0·14	0·16	0·15	0·13	0·14
		2	0·10	0·20	0·24	0·10	0·10	0·16	0·07	0·22	0·19	0·14	0·12	0·16
720–749	Chronic rheumatism and conditions of organs of movement	1	—	0·01	0·03	0·15	0·14	0·08	—	—	0·05	0·15	0·17	0·10
		2	0·05	—	0·01	0·11	0·14	0·07	—	0·03	0·09	0·17	0·12	0·12
750–795	Other and ill-defined conditions	1	0·12	0·10	0·05	0·04	0·05	0·06	0·09	0·09	0·04	0·06	0·08	0·06
		2	0·05	0·02	0·04	0·04	0·04	0·04	0·14	0·09	0·06	0·04	0·08	0·07
N800–995	Injuries	1	0·16	0·20	0·15	0·05	0·09	0·12	0·26	0·17	0·09	0·11	0·12	0·12
		2	0·23	0·19	0·17	0·13	0·03	0·14	0·03	0·16	0·08	0·12	0·12	0·11
N997–999 Y00–09	Immunization, vaccination, reaction to drugs, etc.	1	0·21	0·10	0·06	0·05	0·04	0·07	0·34	0·11	0·08	0·04	0·04	0·07
		2	0·25	0·09	0·03	0·03	0·05	0·06	0·31	0·01	0·04	0·02	0·03	0·04
Total		1	2·67	2·15	1·06	1·05	1·52	1·44	2·54	1·84	1·37	1·42	1·57	1·53
		2	2·93	2·46	1·21	0·99	1·38	1·52	2·31	2·09	1·46	1·41	1·43	1·54

Amongst school children, respiratory diseases again caused the maximum average number of spells per patient. In the first year 0·55 was recorded for boys and 0·57 for girls and in the second year 1·00 and 0·70. These averages approximately represent about 25 to 40 per cent. of all spells in this age group. Infectious diseases accounted for the next highest average and account for about one-sixth of all spells of sickness among school children in the practice.

In the age group 15–39 years the averages were highest for respiratory disorders, 0·20 spells per male and 0·22 per female in the first year, and 0·31 and 0·33 in the second year. These conditions accounted for about 16 to 26 per cent. of all spells in the age group, injuries among men, mental and gynaecological conditions among women, and skin diseases among both sexes being the next most important.

In the age group 40–59 years respiratory disorders were again highest with averages of 0·18 spells per male and 0·22 spells per female in the first year and 0·20 and 0·25 in the second year. These conditions accounted for between 15 and 20 per cent. of all spells in the age group, being followed by chronic rheumatism and conditions of the organs of movement, diseases of the female genital organs, skin diseases, and injuries.

Amongst the oldest patients in the practice, age group 60 and over, respiratory conditions again gave the highest average number of spells per patient among men (0·30 in the first year and 0·27 in the second), accounting for about 20 per cent. of all spells amongst men. Amongst women, the average for respiratory conditions was highest in the second year (0·22, about 15 per cent. of the total), but it was abnormally low (0·13) in the first year. Cardiovascular diseases gave the highest female averages in the first year and about equalled respiratory disease in the second year, the averages being 0·26 and 0·21 spells per patient respectively. The cardiovascular group was second in importance amongst males, and in both sexes these two large groups were followed by chronic rheumatism and conditions of the organs of movement, skin diseases, and diseases of the alimentary tract with hernia.

Table VI indicates several age trends. Those which are consistently portrayed by each year of study are discussed below.

The infectious disease group gave the maximum average number of spells per patient before the age of 15 and thereafter fell with advancing age. Allergic disorders were most frequently encountered in the pre-school children and also diminished with advancing age. Diseases of the central nervous system were at a maximum in the highest age group. Cardiovascular diseases became more common as age advanced. Diseases of the female genital organs were at a maximum in the age group 15–39 years. Chronic rheumatism and conditions of the organs of movement became prominent from the age of 40 years onwards.

Some other age trends are suggested by a study of Table VI, but do not appear consistently. One is left with the impression that male patients were seen less frequently for respiratory conditions in the age groups 15–39 and 40–59 years than in other age groups, while female patients showed a steady downward trend with advancing age for these conditions. It is doubtful whether the data justify further speculation.

No consistent sex differences appear in Table VI and no consistent differences between the two years of study.

Although the large groups in Table VI have in fact been broken down and studied, the value of this analysis is lowered by the small numbers involved, and, except in the case of respiratory disease, these details of morbidity are therefore omitted.

A breakdown of the respiratory group reveals how large a proportion of infections of the respiratory tract were "bronchial" in character. This is clear when the number of spells of acute bronchitis and bronchial catarrh together are expressed as percentages of spells of respiratory illness. In males of all ages this proportion was 53 per cent. and in females 50 per cent. in the first year, 43 and 45 per cent. being observed in the second year. In the 0–4 year age group the percentages were 79 per cent. for boys and 74 per cent. for girls in the first year, compared with 63 and 33 per cent. in the second year. From 5 to 59 years the percentages varied between 31 and 53 per cent. In the age group 60 years and over the percentages were 53 for men and 67 for women in the first year, and 67 and 75 in the second year.

Acute colds comprised only 11 per cent. of all respiratory conditions during the first year, 9 per cent. in the second. More variation occurred for tonsillitis and influenza. The former during the first year comprised only 8 per cent. of respiratory illness, the latter 3 per cent. During the second year the corresponding figures were 17 and 16 per cent. The figures for influenza are, however, still small, and there was no real epidemic during the second year.

It is often said that psycho-neuroses and psycho-somatic disorders generally account for a large part of general practice. An attempt has been made, based on spells of medical attention, to estimate their frequency in this material.

The basis for this grouping of psycho-somatic disorders is wide and includes all cases of allergic and hyperthyroid disease, peptic ulcer and indigestion of uncertain origin, skin conditions with a possible psycho-somatic basis, most of the ill-defined group, and all the psycho-neuroses.

Such spells amount to 345 (16·7 per cent.) of the total spells in the first year and 320 (15·6 per cent.) in the second year.

Although the numbers involved are small, the data suggest that after the age of 15 women experienced relatively more spells of such disorders than men in both years, but no evidence of any other association with age was apparent, except that there is a suggestion of rather high incidence among boys which is mainly attributable to allergic disorders.

TABLE VII

PATIENTS REFERRED TO HOSPITAL EXTERN DEPARTMENTS AND SPECIALISTS DURING THE YEARS 1951–52 AND 1952–53

Patients Referred to		Year	Specialty						Total
			Medical	Surgical and Gynaecological	Rheumatic and Orthopaedic	Ophthalmological	Ear, Nose and Throat	Skin	
Male	Hospital Extern Department	1	17	14	18	4	8	5	66
		2	15	8	13	2	7	6	51
	Specialist	1	12	9	12	2	6	4	45
		2	18	6	2	2	11	4	43
Female	Hospital Extern Department	1	28	13	31	2	5	4	83
		2	17	14	22	2	2	7	64
	Specialist	1	19	12	11	13	8	6	69
		2	24	18	12	11	9	10	84

USE OF HOSPITAL SERVICES AND CONSULTANTS

Tables VII and VIII give an indication of the use made of hospital and specialist services by the patients in this practice. It should be noted that in these Tables an individual patient may appear more than once.

Table VII shows the numbers of patients referred to hospital extern departments and to specialists during the 2 years of study. In different practices the relative numbers naturally vary, but the frequency with which patients elect to go to specialists in this practice may cause surprise. Except in the case of females during the second year, however, hospital externs were rather more frequently attended. During the 2 years there were in all 205 referrals of males and 300 of females. Only fifteen children under 5 years were referred to externs and specialists, seven of these to the ear, nose, and throat department, a speciality which involved about 40 per cent. of the 56 children in the 5 to 15 year group over the 2 years. Many of the patients referred as rheumatic and orthopaedic cases were assigned to the physiotherapy department.

Consultations with specialists usually took place at the specialist's consulting room, but 47 were domiciliary visits undertaken over the 2 years under an arrangement of the Northern Ireland Hospitals Authority. Many patients were prepared to spend a few guineas to see a consultant privately, to avoid the disadvantages of the hospital out-patient department, even with an appointment system there is sometimes considerable delay. The consultation figures, in private and at hospital, include no cases sent only for refraction.

Table VIII shows admissions to hospitals and pay clinics (including nursing homes). In males only, a preponderant use of hospitals as opposed to pay clinics in the first year was completely reversed in the second. This is not easy to explain, but the frequency with which pay clinics were used was undoubtedly due in part to the increasing popularity of associations which insure against the expenses of pay clinics and specialist attention. No cases of eye or skin disease were admitted during either year.

MORTALITY

The deaths in the practice during the 2 years have not yet been mentioned. As these patients were

TABLE VIII

ADMISSIONS TO HOSPITALS OR PAY CLINICS DURING THE YEARS 1951–52 AND 1952–53

Patients Admitted to		Specialty								Total	
		Medical		Surgical and Gynaecological		Rheumatic and Orthopaedic		Ear, Nose, and Throat			
		Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Male	Hospital	6	2	8	2	1	1	3	1	18	6
	Pay Clinic ..	1	8	3	8	—	—	2	6	6	22
	Total	7	10	11	10	1	1	5	7	24	28
Female	Hospital	4	4	5	9	6	3	1	—	16	16
	Pay Clinic ..	4	5	7	9	4	1	3	2	18	17
	Total	8	9	12	18	10	4	4	2	34	33

among those who were not on the register for a full year they were excluded from the main survey.

In the first year there were fifteen deaths, nine of females and six of males, the average age at death being 73 years. The great majority resulted from the effects of old age and arterial degeneration in some form. In these old people the exact pathological factors contributing to death were often difficult to determine and in eight cases the term "cardiac failure" was used; in four of these senile dementia was also present. Two other deaths were due to coronary thrombosis and two more to cerebral haemorrhage and thrombosis. There were two cases of malignant disease and one of embolism following prostatectomy.

In the second year there were ten deaths, four of females and six of males. Cardiovascular disease in old age accounted for five patients, two of which were suffering from senile dementia and one from coronary thrombosis. Malignant disease was responsible for three deaths and one resulted from uraemia with prostatic enlargement. The remaining death was that of a baby 10 days old, caused by a rare virus carditis. Excluding this infant death the average age was again 73 years.

Births

Births have also been excluded from what has gone before. Six male and six female babies were born to mothers who were on the register during the whole of the first year, and six male and three female during the second year.

Midwifery has never been heavy in the practice—possibly twenty cases a year occurred before 1948—and the volume of work is rapidly decreasing because of a decision to discourage midwifery and not to undertake such work under the terms of the Health Service. During the first year ten maternity patients were referred to hospital, six elected to go to specialists, and five were delivered by me. During the second no patients were delivered personally; six were referred to hospital, and five chose to attend specialists.

Comparison of Work done with Work described in Other Surveys

Previous accounts include those of McGregor (1953), 2,562 patients in a rural practice centring on a small town; Fry (1952), a lower middle-class urban practice with a population of 4,456 studied in less detail; Backett and others (1953, 1954), a very full investigation of a working-class practice of 3,084 persons.

There is also the analysis of eight varying practices by Logan (1953) which is a mine of information. It is clear from these studies and my own that the age and sex composition of the patients in the practice plays an important part in the volume and type of work needed. Any comparison between practices must therefore take these factors into account, unless the patients are fortuitously similarly distributed in age and sex groups. It is equally important, if practices are to be compared, that the members should as far as possible be of the same social class.

The age groups in other investigations are not always those of the present survey, but various comparisons may be made. The sex ratio of the present practice averaged 42·05 males per 100 patients for the two years. Fry's figure was 48·25 males per 100 patients, McGregor's 47·07, and that of the General Register Office investigation 44·3. McGregor's figures, and those in Table I show more males than females under the age of 15. The General Register Office figures here are almost identical for the two sexes. The high percentage of the practice (21·8 per cent.) aged 60 years and over is much in excess of the figures for other surveys, Fry's figure, for example, being 13 per cent.

The second year of the present survey was exceptional in that the males required slightly more attention from "all causes" than the females. During the first year of this study, and in the practices of McGregor, Fry, and Backett and others, and all the eight practices of the General Register Office investigation, females always received relatively more attention.

The average number of surgery attendances and home visits combined per patient for the 2 years of the present survey is 3·19, which approximates to the figure given by Fry (3·28) and that in the General Register Office's analysis (3·78). On the other hand McGregor's figure is 5·9, and that of Backett and others is 5·1. All the investigations agree that more frequent attention is given to the very young and to the very old.

The ratio of home visits to surgery attendances in the studies of McGregor, Backett and others, and the General Register Office follows in each case the age pattern to be observed in the present data. McGregor also tabulates frequency distributions of the number of illnesses of his patients, which are essentially identical with the spells of medical attention defined in this paper. Only McGregor gives comparable figures of this nature. The percentages of those who required no medical attention during the year may also be contrasted; those for the present survey, and for McGregor, Fry, and Backett and others are 34·8, 31·4, 25, and 28 per cent. respectively.

SUMMARY

(1) The work done in a Belfast suburban practice during two consecutive years (November to October, 1951–2, and 1952–3) is described.

(2) The statistics, apart from births and deaths, are based on 1,384 patients on the register throughout the first year and 1,341 in the second year, classified by sex and age group (0–4, 5–14, 15–39, 40–59, and 60 and over).

(3) Over the 2-year period there were 3·19 home visits and/or surgery attendances per patient on the register. This index was highest at the extremes of the age range, and at those ages greater among males than females.

(4) Up to age 15 and over age 60 years, home visits were relatively more common than surgery attendances, so that the very young and old required not only more attention but also a different type of attention.

(5) Between 30 and 36 per cent. of the patients on the register were not seen professionally during a year. Up to age 60 this proportion increased with advancing age.

(6) There were approximately 1·5 spells of medical attention per patient in each year, and this average was least among young and middle-aged adults.

(7) The average number of home visits and/or surgery attendances per spell of medical attention varied from about 1·5 in children to about 3 in the oldest age group.

(8) The morbidity data of Table VI focus attention on respiratory disorders. As the predominant cause of sickness in each age group and at all ages they accounted for nearly a quarter of the total number of spells of medical attention.

(9) No consistent differences in the morbidity experience were apparent between the 2 years of study or between the sexes.

(10) Although the numbers involved are small, tentative remarks have been made about the age distribution of some conditions, the "psychoneuroses", and the use made of hospital and consultant services.

(11) Comparison is made with other reported work.

My chief indebtedness is to Dr. E. A. Cheeseman, Reader in Medical Statistics in the Department of Social and Preventive Medicine, The Queen's University of Belfast, for his constant and unfailing help and advice.

Mr. J. D. Merrett and the late Miss Margaret Moran of the Department of Social and Preventive Medicine did much careful and exacting work in the preparation of the figures.

I am most grateful to Dr. J. H. Adams for his help in maintaining the continuity of the records in my absence.

REFERENCES

Backett, E. M., Shaw, L. A., and Evans, J. C. G. (1953). *Proc. roy. Soc. Med.*, **46**, 707.

——, Heady, J. A., and Evans, J. C. G. (1954). *Brit. med. J.*, **1**, 109.

Fry, J. (1952). *Ibid.*, **2**, 249.

Logan, W. P. D. (1953). "General Practitioners' Records". *Studies on Medical and Population Subjects*, No. 7. General Register Office, H.M.S.O., London.

McGregor, R. M. (1949). *Hlth Bull. (Edinb.)*, **7**, 48.

—— (1950). *Edinb. med. J.*, **57**, 433.

—— (1953). *Hlth Bull. (Edinb.)*, **11**, 14.

World Health Organization (1948). "Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death". W.H.O., Geneva; H.M.S.O., London.

Brit. J. prev. soc. Med. (1954), **8**, 91–98

RECENT TRENDS IN SURVIVAL OF PATIENTS WITH RESPIRATORY TUBERCULOSIS

BY

C. R. LOWE

Department of Social Medicine, University of Birmingham

Mortality from most of the common infections has been falling steadily in Great Britain since the end of the 19th century. For a number of these diseases the rate of fall has increased very considerably during recent years, and the improvement has been particularly dramatic in the case of respiratory tuberculosis. The remarkable post-war change in mortality from this disease is illustrated graphically in Fig. 1, which presents the crude mortality from respiratory tuberculosis in Birmingham since 1875.

The death rate fell by half in the 35 years between 1875 and 1910, and again by half between 1910 and 1945. Since about 1947, however, there has obviously been a profound change in the epidemiology of the disease. The rate of fall of mortality has accelerated so rapidly that the crude death rate has been halved yet again in the 6 years between 1945 and 1951 (from 68 to 34 per 100,000) and more than halved in the 3 years between 1949 and 1952 (from 54 to 25).

There seems no reason to question the conclusion of Springett (1952) that medical science can claim little credit for the long slow decline in mortality between 1875 and 1925. As he points out, effective treatment hardly existed before 1920, and even up to 1940 its influence upon mortality was probably trivial. It is true of course that by making it possible to isolate an increasing number of infectious cases, the gradual expansion of hospital accommodation for tuberculous patients which resulted from inclusion of Sanatorium Benefit in the provisions of the National Health Insurance Act of 1911 made some contribution towards the decline. Nevertheless the falling death rate was for the most part an unplanned, uncontrolled, and to some extent unexpected by-product of a steady improvement in general standard of living, with all that this implies in terms of better working conditions, a more varied diet, and more and better houses.

But although it is probably true that until recently the gradual fall in mortality has been due to a rising standard of living, it is not certain whether the improvement is attributable in the main to a decline in incidence of the disease, or to a change in prognosis among those infected. It is significant, however, that in the 25 years between 1913 (when notification of all forms of tuberculosis was made compulsory) and 1938, notifications decreased more rapidly than

FIG. 1.—Crude mortality rate from respiratory tuberculosis Birmingham, 1875–1952 (semi-log scale).

deaths. In Birmingham, for example, the notification rate of respiratory tuberculosis decreased during this period by 80 per cent. (from 483 to 96 per 100,000), while the mortality rate decreased by only 41 per cent. (from 119 to 70). Although notifications are incomplete and notoriously unreliable as an index of morbidity, this striking reduction suggests that the improvement in mortality can be attributed wholly or mainly to a decline in incidence. And if this is true for the period 1913–38, it is probably also true for the preceding half century. Certainly there is no evidence which suggests that there was any substantial improvement in the prognosis of the established case between the end of the 19th century and the beginning of the second world war, and until quite recent times about two-thirds of patients with respiratory tuberculosis died within 5 years of notification (Table I).

TABLE I

REPORTED FIVE-YEAR SURVIVAL RATES OF PATIENTS WITH RESPIRATORY TUBERCULOSIS

Source	Type of Patient	Date of Notification	Proportion of Patients Surviving at Least 5 Years (per cent.)
Thompson (1943)	Sputum positive notifications from County Durham	1928–38	27
Tattersall (1947)	Sputum positive cases attending Reading Dispensary	1914–40	32
Fraser (1947)	Sputum positive notifications from City of Aberdeen and Aberdeenshire	1934–43	45
Acker (1951)	All notifications in Edinburgh	1936–44	54
Present study	All notifications in Birmingham	1930 1935 1945	30 34 45

Since 1947 there has been a sharp increase in the rate at which mortality has been falling, and it seems likely that a new factor has been introduced into the epidemiology of the disease, for although the standard of living has continued to rise since the war, there is little to suggest that this in itself has been sufficient to account for the change. There is also no reason to believe that the improvement is due to a sudden decline in incidence. Indeed, since the beginning of the war in 1939 notification rates have increased, but this increase is apparently attributable to a more intense and successful search for cases, and it seems likely that incidence has continued to fall (Lowe and Geddes, 1953). But even if morbidity is still declining, the rate of decline is certainly not sufficient to account for the abrupt change in mortality.

It seems probable that the recent remarkable improvement in mortality must be attributed mainly to an improvement in prognosis following the introduction of effective chemotherapy. A number of carefully controlled clinical trials (notably those conducted by the Tuberculosis Chemotherapy Trials Committee of the Medical Research Council) have established beyond doubt the value of streptomycin, *p*-aminosalicylic acid, and isoniazid in treatment. But the effect of these agents upon the survival rate has not been measured. In the report which follows an attempt has been made to record how survival rates have changed in the past two decades, by examination of the subsequent histories of patients notified from Birmingham.

SOURCE OF DATA AND METHOD

The greater part of this inquiry is concerned with the year to year survival after notification of all cases of respiratory tuberculosis notified from Birmingham during each of the years 1930, 1935, 1940, 1945, 1947, 1949, 1950, and 1951. Names of patients (approximately one thousand for each of these years) and dates of notification were taken from the official register of notified cases. Persons normally domiciled within the City boundary but found to have respiratory tuberculosis while serving in the armed forces appear in the survival tables from the date on which they were entered in the Birmingham register. All other transfers to the register from outside areas, cases entered after death (*i.e.* not notified during their lifetime), and patients for whom there was no specific mention of respiratory involvement at the time of notification, have been excluded.

For each patient the following data were extracted from the records held in the Birmingham Chest Clinic: sex; age at notification; date last seen alive (or date of leaving the City); (when applicable) date and cause of death. In addition, the state of disease at the time of notification was classified in the three groups suggested by the Ministry of Health (1947):

Group I.—Cases with slight or no constitutional disturbance, no complications (tuberculous or other), and radiological findings limited to mottling involving a total area of not more than one zone.

Group III.—Cases with profound systemic disturbance or constitutional deterioration, including all with grave complications (whether tuberculous or not).

Group II.—All cases which cannot be placed in Groups I and III.

These data were used to prepare Life Tables. The method is illustrated in Table II, which is based on patients (males and females combined) notified during 1935. Mortality rates (qx) for this cohort were calculated for each of the 10 years succeeding notification by dividing the number of patients known to have died from respiratory tuberculosis during each year by the number

TABLE II

ESTIMATED SURVIVAL RATES OF 1,000 PATIENTS NOTIFIED FROM BIRMINGHAM IN 1935

Years since Notification (x)	Number known to be Alive on Each Anniversary of Notification	Number Lost Sight of during Each Year			Number at Risk at Beginning of Each Year	Number Dying from Tuberculosis during Each Year	Probability of Dying from Tuberculosis during Each Year (qx)	Number Alive on Each Anniversary out of 1,000 Notifications (lx)
		Untraced	Left City	Died from Other Causes				
0	995	48	30	5	953·5	349	·3660	1,000
1	563	21	13	2	545	95	·1743	634
2	432	15	6	2	420·5	58	·1379	523
3	351	17	5	3	338·5	50	·1477	451
4	276	16	10	—	263	30	·1141	384
5	220	11	4	1	212	19	·0896	340
6	185	9	6	1	177	11	·0621	310
7	158	17	3	—	148	9	·0608	291
8	129	10	—	—	124	12	·0968	273
9	107	7	2	1	102	3	·0294	247
10	94	6	1	—	92·5	4	·0432	240

presumed to have been at risk at the beginning of the corresponding year. Patients were considered to be at risk until halfway through the year in which they were last examined, had left the City, or had died from some cause other than tuberculosis. The results are summarized as the number alive (lx) on each anniversary out of a thousand notifications.

Much of the value of a Life Table depends upon the proportion of the population at risk which can be followed through succeeding years. In this inquiry no attempt was made to trace patients except through Chest Clinic records; a considerable wastage was therefore inevitable. For example, 8 per cent. of the 1935 notifications were not seen again or had left the city by the end of the first year, and this proportion had risen to 16 per cent. by the end of the fifth year and 25 per cent. by the end of the tenth year (Table II). However, with the exception of 1930 (for which year, owing to the inadequacy of early records, there was a greater wastage), the pattern of loss was very much the same for each of the chosen notification years. Since we are concerned mainly with secular trends in survival there is no reason to believe that the wastage seriously invalidates the conclusions.

CHANGING PATTERN OF SURVIVAL

In the preliminary analysis, sex, age, and extent of disease at notification were disregarded. Table III (see also Fig. 2, overleaf) gives survival tables for the eight notification years examined. Of all new cases of respiratory tuberculosis discovered in 1930 and 1935, only three-fifths were alive 12 months after notification, about one-third were alive after 5 years, and one-fifth after 10 years. These results are compared with previous estimates in Table I. As might be expected, the published findings vary

TABLE III

ESTIMATED SURVIVAL RATES OF 1,000 PATIENTS NOTIFIED FROM BIRMINGHAM IN VARIOUS YEARS

Years since Notification (x)	No. Alive on Each Anniversary out of 1,000 Notifications (lx)							
	1930	1935	1940	1945	1947	1949	1950	1951
0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
1	608	634	546	721	714	785	842	902
2	469	523	419	621	620	709	792	—
3	390	451	351	556	564	648	—	—
4	329	384	312	501	536	—	—	—
5	299	340	274	452	501	—	—	—
6	274	310	237	426	—	—	—	—
7	250	291	210	413	—	—	—	—
8	245	273	188	—	—	—	—	—
9	229	247	164	—	—	—	—	—
10	208	240	154	—	—	—	—	—

according to locality and period, but they are in reasonably close agreement with the Birmingham evidence.

The Life Table for 1940 is even more discouraging. But it must be remembered that at this time there was delay in registration with the appropriate local authority of cases discovered in the armed forces, and that this will inevitably have an adverse effect upon survival after notification. Nevertheless delayed registration is unlikely to have contributed much to the deterioration, since the results in women (of whom a much smaller proportion served in the armed forces) were almost identical with those in men. If this view is correct, the abrupt rise in mortality at the beginning of the war must be attributed to an adverse effect of war-time conditions upon prognosis as well as to an undoubted increase in incidence of the disease.

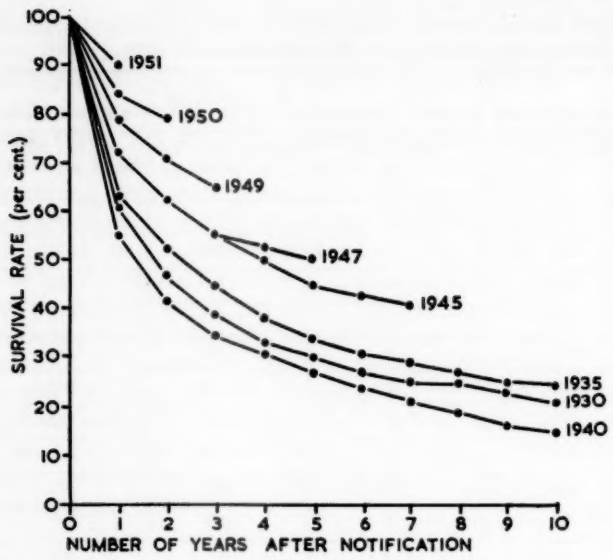

FIG. 2.—Survival rates of patients notified from Birmingham in various years (all notifications).

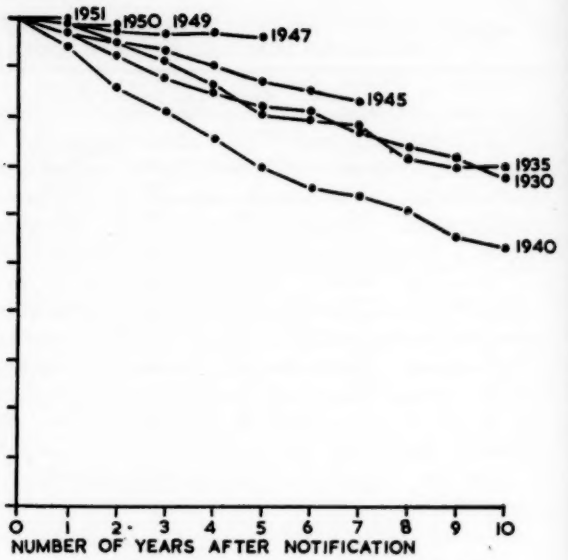

FIG. 3.—Survival rates of patients with Group I disease.

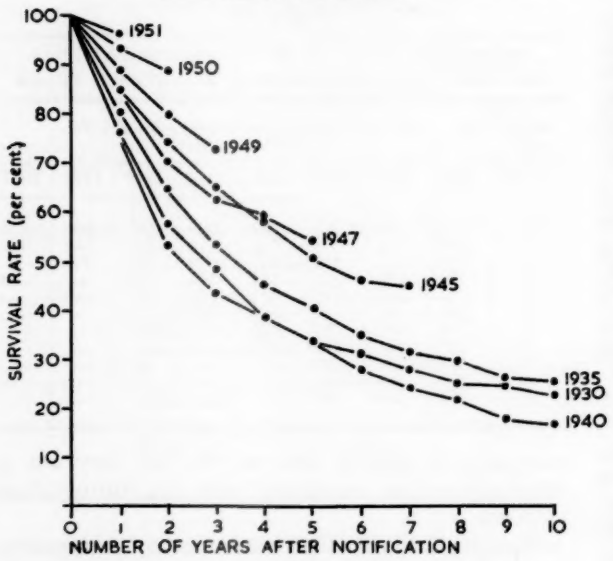

FIG. 4.—Survival rates of patients with Group II disease.

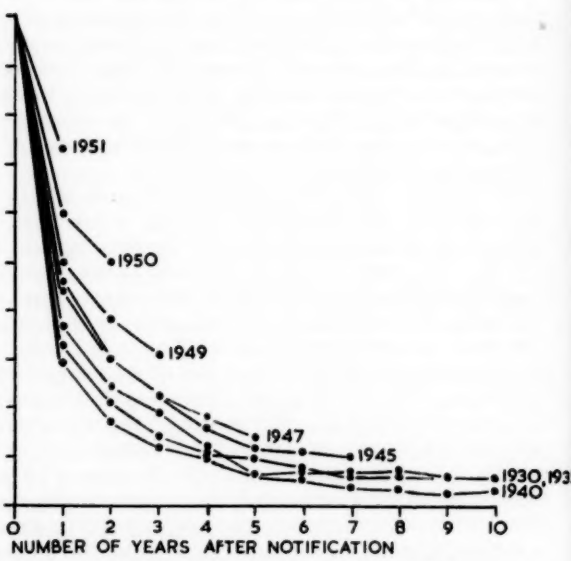

FIG. 5.—Survival rates of patients with Group III disease.

Post-war Life Tables show a remarkable and consistent improvement. For example, for the years 1935 and 1947, the proportions of patients alive 5 years after notification were 34 per cent. and 50 per cent. respectively. For later years the improvement is even more striking, the proportions of patients surviving for one year being 63, 71, 84, and 90 per cent. for 1935, 1947, 1950, and 1951 respectively. Indeed, it seems likely that the 5-year survival rate for patients notified in 1951 will be as high as the one-year survival rate for 1935.

SURVIVAL RELATED TO STAGE OF DISEASE AT NOTIFICATION

It has already been mentioned that the high level of notification in England and Wales since the war has been due to more complete ascertainment, and it seems probable that this has resulted in an increase in the proportion of early lesions among the cases notified. Between 1935 and 1952 the annual number of early (Group I) cases found at the Birmingham Chest Clinic among patients examined for the first time doubled; during the same period the number of

late (Group III) cases was halved (Lowe and Geddes, 1953). Notifications are evidently being progressively diluted with cases which at one time would not have been discovered until they had reached a more advanced stage and carried a much graver prognosis. In addition, tuberculosis registers now include numbers of patients with lesions that would previously have resolved without coming to medical attention. It is likely, therefore, that quite apart from the influence of treatment, some of the recent improvement in survival after notification may be due to earlier and more complete ascertainment. Accordingly the data have been examined in relation to the stage of the disease at notification.

Figs 3, 4, and 5 indicate that there has been a remarkable improvement in survival rate among patients classified in each of the three groups. It is conceivable that the apparent improvement in prognosis of early (Group I) cases may merely reflect the inclusion of increasing numbers of patients with minimal lesions, which a decade ago would have escaped detection. But improvement in case-finding can hardly explain the dramatic change in the survival rate of patients with advanced (Group III) disease: the proportions still alive 12 months after notification were 36, 44, 59, and 73 per cent. for 1935, 1947, 1950, and 1951 respectively. And, what is perhaps even more striking, patients whose disease was advanced when notified in 1951 had a better chance (72 per cent.) of surviving for 12 months than any patient, irrespective of stage of disease, notified in 1935 (63 per cent.).

There can be little doubt, therefore, that the spectacular decline in mortality from respiratory tuberculosis in Great Britain since about 1947, although possibly associated with some decline in incidence, is largely attributable to improvement in prognosis at every stage of disease.

Survival Related to Sex and Age at Notification

In the Life Tables and diagrams so far presented males and females were grouped together and age at notification was disregarded. It is well known, however, that age specific mortality patterns are quite different for the two sexes. Age and sex specific mortality rates for England and Wales in 1951 are shown in Fig. 6; female mortality rates are at their highest in early adult life (in the age group 25–29 yrs), when they are appreciably higher than corresponding male rates; the maximum male mortality rate occurs very much later (65–69 years), when it is many times greater than the female rate. (Indeed in 1951 male mortality in middle and late

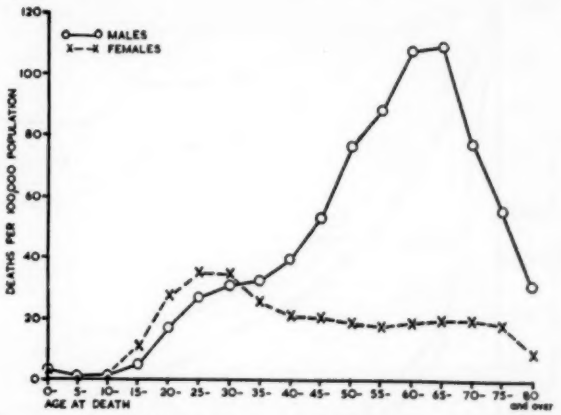

FIG. 6.—Age specific mortality rates from respiratory tuberculosis (England and Wales, 1951).

life was considerably greater than female mortality at any age.) It is clearly necessary to consider the influence of age and sex on survival, and for this purpose notification data for 1935, which permitted a 10-year follow-up, were chosen.

Fig. 7 (overleaf) shows that, among patients with early lesions, males fared better than females (10 years after notification 77 per cent. of males were still alive, compared with 61 per cent. of females); but among patients with moderate or advanced disease the position was reversed. Fig. 8 (overleaf) relates survival to age at notification: under 35 years males did better than females; for the age group 35 years and over, on the other hand, the male survival rates were a little lower than the female rates. These sex differences in respect of age and stage of disease at notification are of course not unrelated, since it is predominantly among young people that early respiratory lesions are found, whereas it is among the middle-aged and elderly that advanced lesions are common.

Notification Rates according to Age and Sex

We have so far been considering the mortality experience of Birmingham patients after notification. With the same data it was possible to examine the notification rates, and this examination revealed an interesting association between notification and age and sex which has been obscured in national figures by the way in which the data are presented.

Fig. 9 (overleaf) gives age and sex specific notification rates for England and Wales, calculated from the report of the Ministry of Health for 1951 and in the One per cent. sample Tables of the 1951 census. Sex differences in notification rates are much less conspicuous than the sex differences in mortality rates shown in Fig. 6. Above 45 years of age

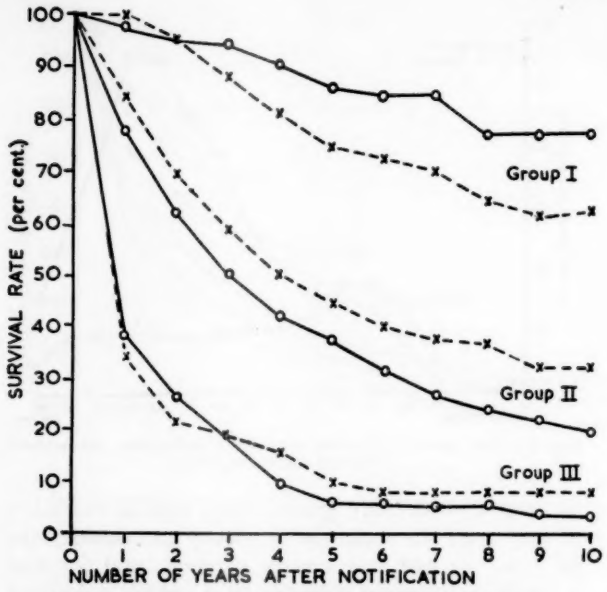

FIG. 7.—Survival rates according to sex and stage of disease (Birmingham, 1935).

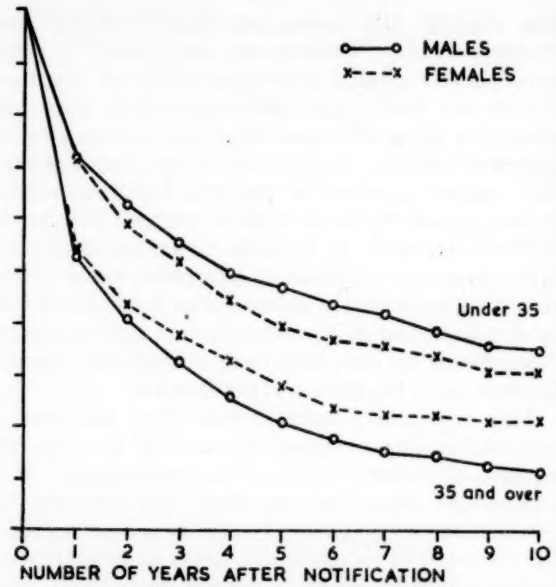

FIG. 8.—Survival rates according to sex and age (Birmingham, 1935).

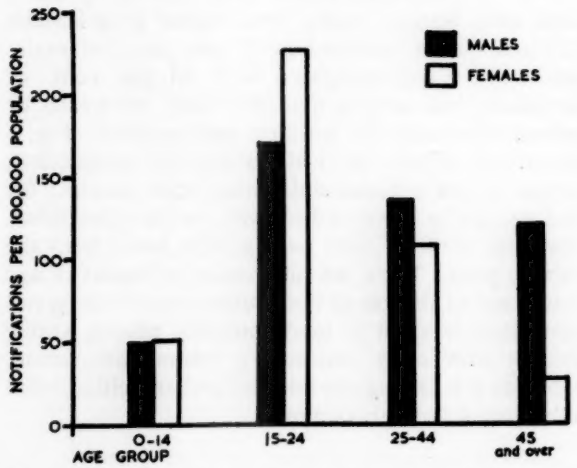

FIG. 9.—Age specific notification rates (England and Wales, 1951).

notification rates are much higher for males than for females, but for both sexes the highest rates are in the age group 15–24 years.

The Birmingham data are presented in Fig. 10(*a*). By giving notification rates in 5-year age groups, they show for males a striking bimodal distribution which is not apparent from the four broad age groups given in national statistics. Male and female distributions are indeed quite different. Female notification rates follow much the same pattern as the mortality rates for England and Wales in the same year: they are comparatively high in infancy, fall during school years, increase very rapidly in the late teens, reach a peak in early adult life, and fall again with advancing years. As might be expected, the peak is earlier for notifications (age group 20–24) than for deaths (age group 25–29). Male notification rates also rise abruptly in early adult life, reach a peak in the same age group (20–24), and thereafter decline rapidly, but after 40–44 years the rate again rises steeply, and reaches a second peak at 50–54 years, 15 years earlier than the age of maximum mortality.

In Fig. 10 (*b*, *c*, and *d*), the Birmingham data for 1951 are also examined according to stage of disease at notification. Female age distributions are much the same for all groups. In males Group II disease shows the characteristic bimodal distribution observed for all notifications, but Group I disease is almost entirely limited to young adults and Group III disease to the elderly. Here it must be mentioned that notification rates for young adult males are somewhat overstated, because census data underestimate the population at risk. (They relate to homepo pulation, whereas notifications include a small number of patients identified while serving in the armed forces abroad). The error introduced is appreciable only in the age groups 15–19 and 20–24; but even here it is not large and in no way invalidates the observations.

Conclusions

The history of the decline of mortality from respiratory tuberculosis in England and Wales is divided into three fairly distinct periods by the two National Health acts of 1911 and 1946. Until 1911 not only was there no effective treatment, but public services designed to control the spread of infection

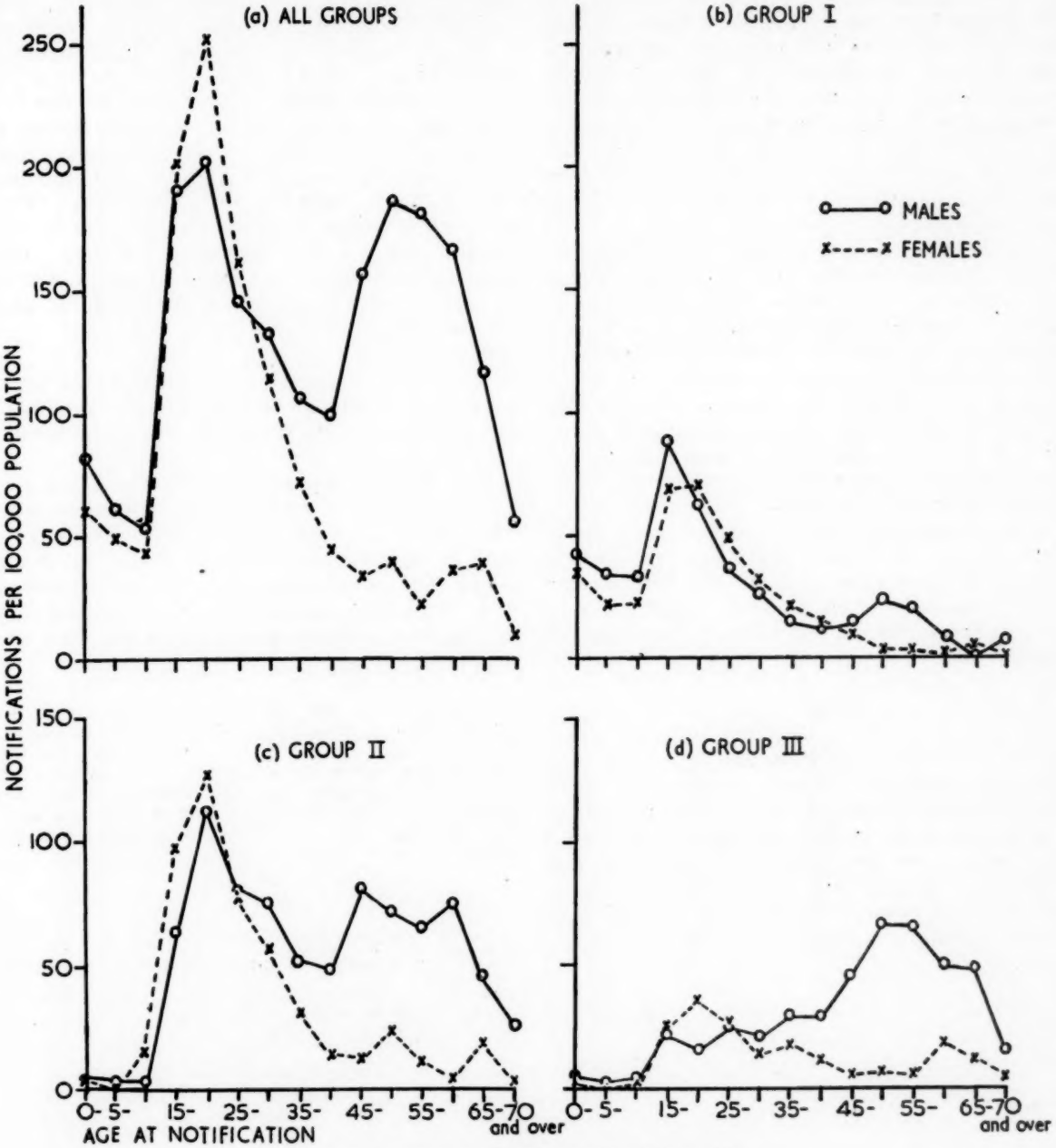

FIG. 10.—Age specific notification rates (Birmingham, 1951).

were badly co-ordinated, unevenly distributed, and altogether ineffectual. Nevertheless, national mortality rates had been falling for at least half a century, and it is reasonably certain that this was due, not to an improvement in prognosis, but to a gradual reduction in morbidity mainly brought about by a rising standard of living.

Between 1911 and 1946 there was a progressive improvement in local authority services directed specifically towards the control of tuberculosis. As in the previous period, a rising standard of living was reflected in a falling mortality rate, but the introduction of more efficient anti-tuberculosis services undoubtedly helped to accelerate the

decline. Focused as they were upon identification and isolation as well as treatment, these services influenced mortality rates principally by reducing the incidence of infection in the community. Nevertheless, it seems likely that in the 10 or 15 years preceding the National Health Service Act, curative medicine was beginning to make some impression on national mortality figures. The improvement in survival rates between 1935 and 1947 supports this conclusion (Fig. 2).

The period since 1946 has been characterized by the introduction of effective therapy. Therapeutic trials have left little doubt about the value of modern treatment, and the present investigation suggests that by effecting a striking improvement in immediate prognosis it has profoundly altered the pattern of mortality. The same methods are also producing very much higher sputum conversion rates (Snell, 1953), and the consequent reduction in the amount of infectious disease is likely to accelerate further the decline of mortality.

There is thus every reason to be encouraged by the contribution which the curative services are now making to the control of tuberculosis. At the same time it should not be forgotten that for nearly 100 years mortality had been falling in the absence of specific curative or preventive therapy, and it would be unfortunate if the new methods which have recently become available should lead us to forget that tuberculosis is an infectious disease, whose course is still largely influenced by social and economic conditions. On the other hand if we apply the new methods with due regard for the continuing importance of the standard of living, it is perhaps not too much to hope that the day is in sight when this formidable disease may be removed from its long-standing position as one of the most common causes of death.

Summary

Data on survival were collected for all cases of respiratory tuberculosis notified from the City of Birmingham during each of the years 1930, 1935, 1940, 1945, 1947, 1949, 1950, and 1951. The material was used to prepare Life Tables.

Of cases notified in 1930 and 1935, three-fifths survived for at least 12 months, about one-third for 5 years, and one-fifth for 10 years. Survival rates for 1940 were even poorer, but post-war rates showed a remarkable improvement. For example, the proportion of patients who survived for 12 months were 63, 71, 84, and 90 per cent. for 1935, 1947, 1950, and 1951 respectively. A similar improvement was evident whatever the stage of the disease. The proportions of Group III (advanced) cases still alive 12 months after notification were 36, 44, 59, and 73 per cent. for 1935, 1947, 1950, and 1951 respectively.

Male survival rates were higher than female rates for Group I disease and for the younger age groups, and lower for Group II and III disease and for the older age groups.

Age specific notification rates for Birmingham in 1951 showed a striking sex difference. Female rates were highest at age 20–24; male rates were also at a peak in this age group, but were again raised at age 50–54. The bimodal character of the distribution of male notification rates is obscured in national data by the wide age groups in which the data are presented.

I acknowledge with pleasure my indebtedness to Dr. Matthew Burn, Medical Officer of Health, and to Dr. J. E. Geddes, Senior Tuberculosis Officer for the City of Birmingham, for the facilities they afforded me for collecting the data used in this paper. I am also grateful to Mr. L. Barratt for help in extracting data from Birmingham Chest Clinic records and to Mrs. M. Hopper for preparing the diagrams.

References

Acker, M. S. (1951). *Edinb. med. J.*, **58**, 489.
Fraser, R. (1947). *Ibid.*, **54**, 566.
Lowe, C. R., and Geddes, J. E. (1953). *British Journal of Preventive and Social Medicine*, **7**, 227.
Ministry of Health (1947). Circular 83/47. Tuberculosis. Revision of Section I of the Appendix to Memorandum 37/T (Revised).
Snell, W. E. (1953). *Lancet*, **1**, 1309.
Springett, V. H. (1952). *Ibid.*, **1**, 521, 575.
Tattersall, W. H. (1947). *Tubercle*, **28**, 85, 107.
Thompson, B. C. (1943). *Brit. med. J.*, **2**, 721.

Brit. J. prev. soc. Med. (1954) **8**, 99–107

BODY-WEIGHT OF MEN RELATED TO STATURE, AGE, AND SOCIAL STATUS

WEIGHT OF SCOTSMEN MEASURED IN 1941

BY

E. M. B. CLEMENTS and KATHLEEN G. PICKETT

From the Department of Anatomy, University of Birmingham

Body-weight has been studied in many different ways and for many different purposes. For example, it forms a part of several anthropometric indices whose object is the definition of physical types (*e.g.* Naccarati, 1921; Sheldon, Stevens, and Tucker, 1940); it may be used as a measure of growth, as in the Harvard Growth Study (Shuttleworth, 1937); it is also regarded as a pointer to clinical conditions, and so is observed as a routine in physical examinations. There is good reason for doing this, since insurance records indicate that mortality differs amongst men of different weights (Fisk, 1923), and since there is also evidence that some clinical conditions occur more frequently in men of certain physiques than in others (Draper, 1924). In view of the subject's wide significance, it is not to be wondered at, therefore, that numerous statistics on body-weight have been compiled (Kemsley, 1952).

It should be observed that data about body-weight are regarded as a measure. If, however, a measure is to be treated as a standard, the conditions under which the measure varies should be clearly recognized. Unfortunately, this has rarely been the case in discussions of body-weight. The available series of data are deficient: sometimes because they are inadequate statistically; sometimes because they appear to relate to a whole population when, in fact, they apply only to a particular section; sometimes because data about one population are treated as though applicable to a different one; and almost always because the influence of social and economic factors, which change with the passage of time, is overlooked, so that figures collected, say, 20 or even 40 years ago, continue to be treated as a standard for the present day.

It is the purpose of this paper to reveal the importance of these issues by a detailed analysis of records relating to a single homogeneous population. Because they satisfy the basic requirements of the analysis, and because they were readily available, the figures used are those for Scotsmen contained in the war-time (1939–45) medical records of the Ministry of Labour and National Service.

Material

The analysis is based on measurements recorded on 3,692 men who were medically examined by the Scottish medical boards of the Ministry of Labour and National Service in 1941. An account of the material used and of the information abstracted from the records has already been published (Clements and Pickett, 1952). In the course of this earlier analysis it became apparent that the National Service records of men refer to a random sample within occupations and age groups, but that the numbers in the groups are not in proportion to their occurrence in civil life. The age range of the records extends only from 18 to 40 years, so that no elderly men are included in the material. Nevertheless the changes in body-weight with age are very similar to the findings of a recent survey (Kemsley, 1952) which includes men in the older age groups, and there can be no doubt that the data have been sufficient to establish the main changes in body-weight with age.

Anthropometric Data—The subjects were weighed, wearing trousers only, on weighing machines of the "Steelyard" type, reading accurately to 2 oz. The accuracy of the machines was checked periodically. A few records were to fractions of a pound, and in the process of abstracting the data, all records of fractions of ½ lb. or more were taken to the pound above. A frequency distribution of the measurements of weight by intervals of 1 lb. shows no serious bias in recording the weight. Nevertheless, the exact stone and half stone are favoured measurements, and weights recorded to an even number of pounds are more frequent than those recorded to an odd number of pounds.

Results

Analysis of Data on Weight.—The mean weight for the whole sample of 3,692 records is 138·2 ± 0·3 lb. The mean weight of Scotsmen aged 20·5 years is 136·3 lb., and the mean for 9,623 native Scotsmen aged between 20 and 21 weighed in

TABLE I
MEAN WEIGHTS FOR REGIONS BY AGE GROUPS

Region	Age Groups				All Ages
	17–19	20–29	30–39	40–42	
Southern	136·7±1·4 (130)	143·6±1·5 (140)	141·3±1·8 (138)	— (1)	140·6±0·9 (409)
West Central ..	131·3±0·7 (366)	136·2±0·9 (384)	137·2±1·0 (339)	133·6±4·0 (14)	134·8±0·5 (1,103)
East Central	133·3±1·0 (258)	137·4±0·9 (320)	136·2±1·0 (317)	—	135·8±0·6 (895)
Northern	138·1±0·9 (318)	142·3±0·9 (337)	143·1±0·8 (601)	152·3±4·4 (29)	141·9±0·5 (1,285)
Total	134·4±0·5 (1,072)	139·1±0·5 (1,181)	139·9±0·5 (1,395)	146·5±3·4 (44)	138·2±0·3 (3,692)

Means in lb. Numbers in each sample shown in brackets.

the nude in 1939 is 135·3 ± 0·2 lb. (Martin, 1944). Martin states that in 1939 the men were measured nude. Evidently 20-year-old men in 1941 may have been 1 lb. lighter, on the average, than those in 1939, after allowing 2 lb. for the weight of trousers.

The medical boards were grouped into the four regions used by the Registrar-General for Scotland. The mean weights for the regions are set out in Table I. Those for the Northern Region have the greatest mean weight and those from the West Central Region the lowest. The mean weights, alsd set out by age groups in Table I, show an upwaro trend with increasing age.

The statistics presented in Table I relate to heterogeneous data so far as socio-economic groups are concerned. The records were therefore separated into the social classes of the Registrar-General according to the man's stated occupation. Certain samples of small geographical areas, termed "separate" areas, showed a significant variation in stature from the mean for the whole region of which they were isolated parts, and these have been excluded from the data relating to each social class. The study of the "separate" areas indicates the extent of the geographical variation, and this is given in detail in a later section. The reclassified data are shown in Table II (opposite), which gives the mean weights of the samples of men by region and social class, standardized to an age of 26 years and a height of 67 inches, so as to take into account differences in the distribution of stature and age in the samples. The average weight of the sample of men in Social Class 1.2 from the Northern Region is 145·3 ± 2·0 lb. and the samples from this region have the greatest mean weights in every social class. In Social Class 1.2, the sample from the West Central Region has the smallest mean weight, 138·4 ± 1·2 lb. However, little difference exists between the average weights of the samples of men from the East and West Central Regions in each class, and one or other of these samples always provides the smallest mean weight.

DISTRIBUTION OF MEASUREMENTS OF WEIGHT.—The distribution of weight and the relationship of weight to both stature and age have been determined for the samples of each social class.

Measurements of body-weight are not Normally distributed when they are measured in pounds, but if they are transformed into a logarithmic scale the resulting distribution is almost Normal (Kemsley, 1952; Yuan, 1933). This finding has been confirmed by our own samples.

The samples from the social classes were examined separately by the method described by Snedecor (1946). The statistics indicating kurtosis and skewness were significant, thus indicating an excess of records round the mean and at the end of the distribution. After making a logarithmic transformation of the data the statistics were no longer significant in three out of four of the samples examined, but the exceptional sample (that of Social Class 4) still had a positive kurtosis after transformation. After combining the material for all the social classes, a comparison of the observed frequencies after transformation with the calculated frequencies assuming a Normal distribution shows that the distribution is not Normal ($\chi^2 = 35{\cdot}8$, *d.f.* 17). However, only three groups show a large variation between the observed and expected frequencies, and these occur in the middle of the distribution. There were no obvious discrepancies at either end of the distribution, and it may therefore be regarded as Normal for all practical purposes.

The variances of the log-weight distributions within groups of stature having a 2″ range are shown to be homogeneous by Bartlett's test (Bartlett, 1937). Thus the bivariate distribution of stature and the logarithm of weight is homoscedastic. These findings imply that a logarithmic scale rather than the more usual arithmetical one is more suitable for recording measurements of body-weight. The mean weight in pounds derived from the data after recording them on a logarithmic scale is 136·6; this approximates to the median value of 136·9 lb. and is about 2 lb. less than the arithmetical mean of the untransformed data. The relationship between the mean values may be expressed as follows:

Observed mean weight (lb.) = 1·045 mean log-weight (lb.) − 5·098.

TABLE II

MEAN WEIGHTS RELATED TO SOCIAL CLASSES AND GEOGRAPHICAL REGIONS

Data	Region	Social Class 1.2	Social Class 3	Social Class 4	Social Class 5
Derived from measuring weight in pounds avoirdupois	Southern ..	142·1±3·2 (28)	—	143·0±1·9 (85)	—
	West Central ..	138·4±1·7 (105)	138·9±0·7 (542)	140·1±1·3 (188)	140·8±1·1 (174)
	East Central ..	139·6±2·1 (77)	138·9±0·8 (455)	140·3±1·5 (136)	139·7±1·1 (227)
	Northern ..	145·3±2·0 (129)	143·3±0·8 (464)	143·2±1·5 (163)	144·7±0·9 (319)
	Total	141·7±1·1 (339)	140·2±0·4 (1,461)	141·5±0·8 (572)	142·2±0·6 (720)
Derived from logarithm of measured weight (lb.)	Southern ..	2·1498±0·0095	—	2·1519±0·0059	—
	West Central ..	2·1375±0·0054	2·1395±0·0022	2·1428±0·0040	2·1460±0·0037
	East Central ..	2·1411±0·0066	2·1394±0·0024	2·1439±0·0045	2·1420±0·0035
	Northern ..	2·1577±0·0056	2·1528±0·0025	2·1523±0·0045	2·1575±0·0029
	Total	2·1470±0·0032	2·1437±0·0014	2·1471±0·0023	2·1498±0·0019
Means for regional samples homogeneous for log-weight after excluding heterogeneous areas	West Central ..		2·1450±0·0032 (276)		
	East Central ..		2·1406±0·0028 (355)		
	Northern ..		2·1476±0·0038 (220)		2·1409±0·0055 (87)
	Total		2·1439±0·0018 (851)		2·1432±0·0023 (488)

Medical boards comprising regional samples are homogeneous except where indicated for stature and for weight measured as the logarithm of weight.
Mean weights standardized to age 26 yrs, and height 67 in.

The weight of each man has been transformed into the logarithm (to base 10) of the weight in pounds (henceforth referred to as "log-weight") and the relationship of weight to other variables has been investigated using measurements of weight in this form.

The standard deviation of the whole distribution of weight in men is 17·8 lb. (0·0553 log lb.) when measured on the transformed scale. Clearly, in a measurement with so large a variance, the distribution must always be taken into account, and this implies that mean weights should only be used as descriptive statistics.

RELATIONSHIP OF WEIGHT TO STATURE.—The bivariate distribution of log-weight and stature is given in Table III. For convenience, the stature groups have a span of 2 in. in the Table, but the computations have been made on the ungrouped data. The coefficient of correlation between the two measurements is 0·595 and compares with the average value of 0·61 found in the past for weight and stature (Kemsley, 1952). If the relationship between two variables is linear it may be expressed in the form of a regression equation $y = a + bx$, where x and y are variables, a is a constant, and b is the regression coefficient. The last statistic indicates

TABLE III

DISTRIBUTION OF BODY-WEIGHT (log lb.) AND STATURE (in.)

Log-weight	Stature 57–58·99	59–60·99	61–62·99	63–64·99	65–66·99	67–68·99	69–70·99	71–72·99	73–74·99	75–76·99
2·350–2·399 ..	—	—	—	—	—	—	—	1	1	—
2·300–2·349 ..	—	—	—	—	—	2	2	2	0	—
2·250–2·299 ..	—	—	—	1	7	13	17	11	5	—
2·200–2·249 ..	—	—	2	6	42	87	90	42	17	1
2·150–2·199 ..	—	2	7	60	199	273	213	74	7	—
2·100–2·149 ..	—	2	33	198	414	370	125	18	6	—
2·050–2·099 ..	1	8	67	170	188	102	18	—	—	—
2·000–2·049 ..	4	14	52	60	34	8	—	—	—	—
1·950–1·999 ..	0	3	6	2	3	—	—	—	—	—
1·900–1·949 ..	2	—	—	—	—	—	—	—	—	—
99th centile ..	2·1309	2·1552	2·1795	2·2038	2·2282	2·2525	2·2768	2·3012	2·3255	2·3498
Observed mean ..	2·0120	2·0518	2·0731	2·1021	2·1264	2·1474	2·1711	2·1937	2·2093	2·2175
Mean from regressions	2·0283	2·0526	2·0769	2·1012	2·1256	2·1499	2·1742	2·1986	2·2229	2·2472
1st centile	1·9257	1·9500	1·9743	1·9986	2·0230	2·0473	2·0716	2·0960	2·1203	2·1446

that the variable y increases a constant amount for each unit increase in the other variable. The observed mean log-weights, and the estimated values derived from regression, are given for stature groups in Table III. It will be seen that they are very similar, a finding which suggests that the relationship between log-weight and stature is linear, and this relationship was confirmed by an analysis of variance after grouping the data on stature into groups with a range of 1 in. Thus, itmay be concluded that, when expressed in log lb., the rate of increase in weight is, on the average, the same for equal increases in stature measured in inches. Other recent data (Kemsley, 1952) indicate that the relationship of body-weight (lb.) and stature is linear for practical purposes. Probably because of the limited range within which the mean values occur, the trends of mean body-weights with increasing stature are much the same for measurements of weight recorded either on an arithmetical or logarithmic scale.

The regression coefficients relating log-weight to stature have been calculated from the data for the social classes separately. The coefficients do not differ significantly, so that the estimates have been pooled, and the best estimates of the regression coefficient (b) is $+ 0{\cdot}0122 \pm 0{\cdot}0003$ log lb./in. This analysis establishes the following relationship between stature and log-weight:

Log-weight (log lb.) = 0·0122 Stature (in.) + 1·323.

The values corresponding to the mean, the 1st, and the 99th centiles of the weight distribution for each stature group are given in Table IV in log lb.; these results have been transformed into pounds weight, and the regression, 1st, and 99th centile lines for weight on stature are given in Fig. 1.

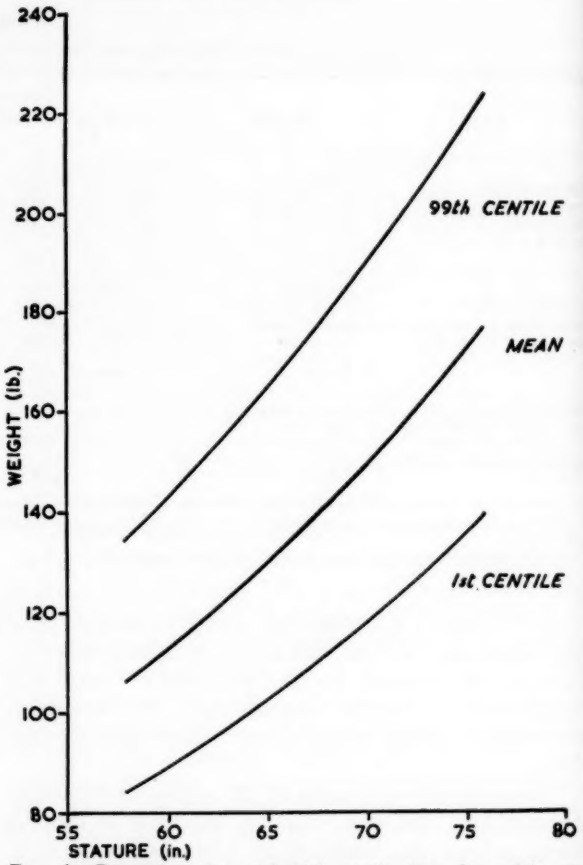

FIG. 1.—Regression, 1st, and 99th centile lines for weight on stature Values calculated in log lb. have been transformed into pounds avoirdupois.

RELATIONSHIP OF WEIGHT AND AGE.—A bivariate frequency distribution of log-weight and age is given in Table IV with the mean values at each age.

TABLE IV

DISTRIBUTION OF BODY-WEIGHT (log lb.) AND AGE (yrs)

Log-weight	Age												
	17	18–19	20–21	22–23	24–25	26–27	28–29	30–31	32–33	34–35	36–37	38–39	40–41	42–
2·350–2·399 ..	—	—	—	—	—	—	—	—	1	—	1	—	—	—
2·300–2·349 ..	—	1	1	—	—	—	—	—	—	1	3	—	—	—
2·250–2·299 ..	—	5	8	—	2	2	3	4	7	6	14	3	—	—
2·200–2·249 ..	—	46	41	4	10	20	30	25	15	31	60	1	3	1
2·150–2·199 ..	—	210	151	9	21	44	52	74	45	66	141	16	6	—
2·100–2·149 ..	1	363	237	9	25	62	61	74	56	65	186	15	12	—
2·050–2·099 ..	2	192	106	3	8	23	18	32	27	32	97	10	4	—
2·000–2·049 ..	—	47	40	1	2	8	9	6	8	8	31	10	2	—
1·950–1·999 ..	—	5	1	—	—	1	—	—	—	1	5	1	—	—
1·900–1·949 ..	—	1	—	—	—	—	—	—	—	—	1	—	—	—
99th percentile ..	2·2373	2·2415	2·2457	2·2499	2·2539	2·2579	2·2618	2·2657	2·2697	2·2735	2·2773	2·2810	2·2848	2·2885
Observed mean ..	2·0875	2·1258	2·1309	2·1453	2·1532	2·1410	2·1487	2·1444	2·1443	2·1497	2·1371	2·1195	2·1334	2·2480
Mean from regressions	2·1283	2·1298	2·1313	2·1329	2·1344	2·1359	2·1374	2·1389	2·1405	2·1420	2·1435	2·1450	2·1466	2·1481
1st percentile ..	2·0193	2·0181	2·0169	2·0159	2·0149	2·0139	2·0130	2·0121	2·0113	2·0105	2·0097	2·0090	2·0084	2·0077

For convenience the age groups have a span of 2 years in the Table, but the computations have been made on the data grouped into intervals of 1 year.

The relationship between weight and age is difficult to express mathematically; both linear and quadratic* equations have been fitted to the data for each social class. The regressions of log-weight on age, both with and without the square of age, are parallel in the different social classes, but the mean weights of each class differ significantly. The regression coefficients may therefore be pooled but the constants of the equations will differ. This finding is expected, because the data have not been standardized for stature differences.

The estimated value of the linear regression coefficient (b_1) is $+0{\cdot}00076 \pm 0{\cdot}00013$ log lb./yrs.

The constant takes the following values:

Class 1.2 + 2·116; Class 3 + 2·115;
Class 4 + 2·108; Class 5 + 2·128;
Pooled Classes + 2·115.

These statistics provide the relationship:

Weight (log lb.) = Constant + 0·00076 Age (yrs).

The estimated values of the regression coefficients for the quadratic relationship are:

$b_1 = +0{\cdot}0115 \pm 0{\cdot}0017$
$b_2 = -0{\cdot}00020 \pm 0{\cdot}00003.$

The constant takes the following values:

Class 1.2 + 2·024; Class 3 + 1·950;
Class 4 + 1·960; Class 5 + 2·016;
Pooled Classes + 1·979.

These statistics provide the relationship:

Weight (log lb.) = Constant + 0·0115 Age (yrs) − 0·00020 $(\text{Age})^2$.

The quadratic equation gives a better fit over the age range of 17 to 30 years, but the linear regression is more satisfactory after age 30.

The values corresponding to the mean, the 1st, and the 99th centiles of the weight distribution in each age group have been derived from the linear regression and are given in Table IV in log lb. These results have been transformed into lb. weight and the regression, 1st, and 99th centile lines for weight on age are given in Fig. 2.

The mean weights show the same trend with age as do both the war-time survey made by the Ministry of Food (Kemsley, 1950), and a survey of Royal Air Force personnel (Morant, 1946). A steady increase in mean weight occurs up to age 30, a trend which is similar to that shown by all earlier reports. After age 30, changes in the mean weights are small. This

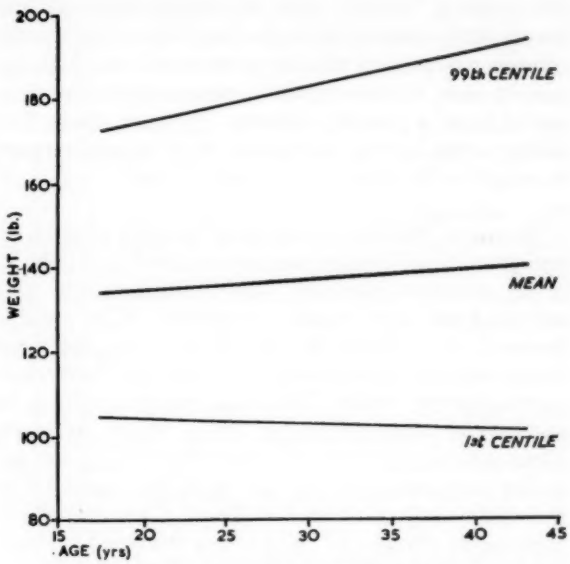

FIG. 2.—Regression, 1st, and 99th centile lines for weight on age.

result contrasts strongly with those of earlier studies, all of which indicate an increase in weight with age after the 30th year has been passed (see Kemsley, 1952). Kemsley's data show that the trend of mean weight with age in men older than 40 years is similar to that found for men aged between 30 and 40 years. These findings may reflect war-time conditions, and it is uncertain whether they apply to present-day conditions. However, the fact that a similar trend exists amongst American service personnel (Newman, 1952) suggests that the findings cannot be entirely attributed to war-time rationing.

The variance of body-weight expressed in log lb. is not homogeneous in each age group. It increases from 0·0023 log lb. in men aged 18 to 19 years to 0·0041 log lb. in those aged 38 to 40 years. The observed variances have been smoothed by fitting a linear regression, and the resulting smoothed values have been used to provide estimates of the 1st and 99th centile limits of body-weight in each age group. These estimates are based on the mean weight at each age after smoothing the observed values by a linear regression. (For convenience, a linear regression has been employed over the whole age range). It is apparent that the values of the 1ts centile change from 104 lb. at age 18–19, to 102 lb. at age 36–37. These values represent the lower limits of the distribution and only diverge slightly from the trend of the mean values. On the other hand, the 99th centile, which may be taken to represent the upper limit of the distribution, diverges considerably. The 99th centile limit at age 18–19 is 174·4 lb., and at age 36–37 is 189·4 lb. These findings confirm those

* Equations of the form

$$y = a + bx + cx^2,$$

where x and y are variables, a is a constant, b is the regression coefficient for the 1st degree term, and c is the regression coefficient for the 2nd degree term.

of Kemsley (1952) who concluded that, if the assumption is made that men retain about their same relative position in the distribution of weight from year to year, the increase in mean weight with age is not due to a general increase by every man, but rather to the fact that some men show large increases in weight while others show little or none.

SECULAR TRENDS.—The mean weights of men by age groups and social classes are given in Table V, in lb. derived from the untransformed data and standardized for height, together with similar material (for Great Britain) which was recorded about the year 1880 (British Association Anthropometric Survey, 1883). The mean weight increases in each social class up to the age of about 30 years. The succeeding period of 10 years shows little change in the mean weights with age, with the exception of the mean weights of men in Social Class 1·2 which increase by about 7 lb., and where the trend is much the same as in earlier studies.

The mean weights of men aged 20–29 years in all the social classes are greater than the corresponding samples of men aged 17–19 years, but the increase in weight over the period is not the same in each social class. The early data which are available suggest that the differences are now less than they used to be, because young men under 20 years of age weigh more, on the average, than they used to. For example, the mean weight of men in Social Class 3 aged 20–29 years in 1941 is 3·7 lb. more than that of the sample of men aged 17–19 years, whereas the difference in 1880 was 9·4 lb.

STANDARDIZATION OF LOG-WEIGHT FOR STATURE AND AGE.—The relationship of log-weight to the variables of stature and age taken together requires consideration. The partial regression coefficients have been derived from a multivariate analysis. The coefficient on stature is always significant, but in Class 1.2 neither age nor the square of age is significant, largely because of the higher error attributable to the smaller numbers. The regressions relating log-weight, stature, and age have been examined within the different social classes by means of a covariance analysis, because, although the variances about the within-class regressions are not homogeneous, the amount of heterogeneity is unlikely to affect the conclusions arrived at by pooling the regressions. The regression coefficients do not differ significantly and the best estimates have been derived from the data for the pooled social classes.

The partial regression coefficient relating log-weight and stature (b), keeping age constant, is:

$$+ 0{\cdot}0127 \pm 0{\cdot}0004.$$

The partial regression coefficients relating log-weight to age (c) and the square of age (d), keeping stature constant, are respectively:

$+ 0{\cdot}0103 \pm 0{\cdot}0017$ and $- 0{\cdot}000168 \pm 0{\cdot}000031$.

These statistics taken together establish the following relationship:

$$\text{Weight (log lb.)} = 1{\cdot}141 + 0{\cdot}0127\ \text{Stature (in.)} + 0{\cdot}0103\ \text{Age (yrs)} - 0{\cdot}000168\ (\text{Age})^2.$$

In the remaining sections of this paper, the significance of differences between mean log-weights have been tested by multiple covariance analyses which take into account the differences in mean stature and age (including the square of age) between the samples.

GEOGRAPHICAL FACTORS.—The geographical variation in weight within a region is indicated by the detailed study of the data relating to the "separate" areas already referred to. The mean log-weight was calculated for each of the medical boards included in a region. When a significant difference was found, the sample for the medical board showing the greatest discrepancy when compared with the mean

TABLE V

STANDARDIZED MEAN WEIGHTS OF SCOTSMEN BY AGE GROUP AND SOCIAL CLASS

Age Group (yrs)	Data for Scotsmen				Comparable data from British Association Anthropometric Survey, 1883	
	Social Class				Social Class	
	1.2	3	4	5	1.2	3
17–19	132·7±1·8	134·5±0·6	135·3±1·2	135·2±1·2	131·4±0·3*	127·2±0·6*
20–29	137·7±1·7	138·2±0·7	139·7±1·2	142·1±1·1	138·2±0·4	136·6±0·6
30–39	144·7±1·9	140·5±0·9	142·0±1·2	141·2±0·8	154·7±1·6	146·8±1·2

* Variances derived from Scottish data.

Comparable data from B.A.A.S. (1883) have been standardized for stature and included for convenience. Seven pounds allowed for weight of clothing.

Mean weights standardized to a height of 67 in.

for the whole region was removed from the combination of boards and became a "separate" area. The procedure was repeated whenever it was necessary, until the remaining boards were homogeneous. The mean log-weights of the regions are given for each Social Class in Table II.

Social Classes 1.2 and 4 required no adjustment, but the areas represented by six medical boards in Class 3 and by three boards in Class 5 were defined as separate areas for weight. The mean log-weights for these areas, together with the mean log-weights of the separate areas previously defined for stature, are given in Table VI. The findings for weight and stature are remarkably consistent.

The samples of men from Lerwick for Social Classes 4 and 5, and from Wick for Social Classes 3 and 4, differed from the Northern Region on evidence provided by measurements of stature. A further class of each board is not homogeneous with the rest of the region when the measurement of log-weight is analysed; thus the areas of Lerwick and Wick are separate areas for Social Classes 3, 4 and 5. The mean log-weights of men in Social Classes 3 and 5 at Kirkwall and Inverness differ from the mean log-weight of the rest of the region. The Northern Region may thus be separated into two parts:

Part 1 includes Lerwick, Kirkwall, Wick, and Inverness, where either the mean stature or the log-weight is above average in Social Classes 3 and 5 (and also in Class 4 for Lerwick and Wick.)

Part 2 comprises the urban areas of Aberdeen and Perth.

The mean statures of samples of men in Social Class 5 from Paisley and Glasgow are below the average stature for the West Central Region, and the mean weight of the sample of men from Social Class 3 from both these areas is below the average weight of the Region.

The mean weight of men in Social Class 3 is less in Edinburgh than in the rest of the East Central Region.

The mean weight of the homogeneous and adjusted regions proved to be homogeneous for each social class, and these have been combined into a national sample for each social class. The means of each of these samples are given in the "Total" entry in the centre and lower parts of Table II.

WEIGHT RELATED TO SOCIAL CLASS.—The unstandardized mean weights of the samples of the social classes look different. For example, the mean weight of Social Class 1.2 is 141·6 lb. whereas that of Social Class 5 is 134·9 lb.

The differences between the mean weights of the national samples of the social classes are, however, not significant after standardizing for both stature and age (including the square of age). It is clear that the apparent differences between the mean weights of the classes are mainly accounted for by differences in stature.

Comparison with earlier data is difficult because of the need to use the untransformed data and to standardize the material before making the comparison, but it seems that the mean weight of men in Class 1.2 at age 18 to 19 and 20 to 29 and of men in Class 3 at age 20 to 29 have changed little over the years, as is evident from Table V, which gives the mean weights in 1883 of British men

TABLE VI

MEAN LOG-WEIGHT* OF MEDICAL BOARDS COMPRISING SEPARATE AREAS

Region	Board	Social Class		
		3	4	5
Southern	Dumfries ..	2·1473±0·0053 (104)†	—	2·1442±0·0079 (62)†
	Galashiels ..	2·1423±0·0063 (97)†	—	2·1520±0·0085 (33)†
Northern	Lerwick ..	2·1560±0·0075 (58)	2·1628±0·0089 (31)†	2·1548±0·0078 (59)†
	Kirkwall ..	2·1522±0·0055 (79)	—	2·1596±0·0039 (104)
	Wick ..	2·1411±0·0071 (78)†	2·1460±0·0069 (42)†	2·1510±0·0071 (66)
	Inverness ..	2·1458±0·0048 (107)	—	2·1506±0·0077 (62)
West Central	Paisley ..	2·1269±0·0050 (111)	—	2·1322±0·0066 (63)†
	Glasgow ..	2·1314±0·0037 (155)	—	2·1312±0·0095 (31)†
East Central	Edinburgh ..	2·1294±0·0050 (100)	—	—

* Weights standardized to age 26 yrs and height 67 in.
† Boards defined as separate areas because of their unusual mean stature.
Numbers in each sample shown in brackets.

in Social Classes 1.2 and 3 in three age groups after standardization for stature differences. On the other hand, men aged 18 to 19 in Class 3 now weigh, on the average, 1·8 lb. more than men of the same age in Class 1.2, whereas they weighed 4·2 lb. less in 1883. Men aged between 30 and 39 years in Class 1.2 weighed, on the average, about 4 lb. more than those in Class 3 in 1941, whereas they weighed about 8 lb. more, on the average, in 1883. Both samples show a considerable reduction in mean weight (10 lb. in Class 1.2 and 6 lb. in Class 3) attributable to the different trend of mean weights with age already discussed.

WEIGHT RELATED TO OCCUPATION.—The standardized mean log-weights of samples of men in various occupational orders have been compared within each social class. The mean weights of men following the different occupational orders in Social Class 1.2 differ significantly at the 1 per cent. level of probability, mainly because of the above-average mean weights found in the two groups of "manager" which are both approximately 13 lb. heavier (after standardization) than the mean weights of men in the remaining occupations in this class. The mean weights of the occupational groups in Social Class 4 differ at the 5 per cent. level of probability. No occupational group differs particularly from the rest, and the finding is rather the expression of a general heterogeneity within the social class.

WEIGHT RELATED TO MEDICAL FITNESS FOR MILITARY SERVICE.—The mean weight of men classed as fit for military service is 4 lb. greater than the mean weight of men classed as unfit. The difference is significant at the 1 per cent. level of probability. When the social classes are examined separately, fit men, on the average, are found to be significantly heavier than unfit men in Social Classes 3 and 4, but the difference is not significant in Social Classes 1.2 or 5. The difference is, however, in the same direction in Class 5, but the mean weights of fit and unfit men in Class 1.2 are almost identical.

WEIGHT RELATED TO CLASSIFICATION AS VOLUNTEERS OR CONSCRIPTS.—The mean weights of volunteers do not differ significantly from the mean weights of conscripts, either when the social classes are pooled or when they are examined separately.

This finding confirms the conclusion derived from the analysis of measurements of stature: that, physically, volunteers do not differ from conscripts, and it disposes of any doubt that the large number of volunteers who joined the forces in 1939 and 1940 may have affected the validity of the sample.

DISCUSSION

The results of the analysis described in this paper confirm the general impression that body-weight is a good means of assessing physique. However, weight is associated with other factors, which should be taken into account whenever an assessment is made.

Weight and stature are highly correlated measurements, and this implies that, on the average, tall men weigh more than short men. The regression coefficients relating weight to stature and age are the same for men in each social class. It would follow that, for many practical purposes, variation in weight attributable to social factors can be disregarded if the variables of stature and age are taken into account. The similarity of the regression coefficients under the very diverse environmental conditions present in Scotland is good evidence that coefficients relating anthropometric measurements are stable.

The normal variation in body-weight from one person to another is great, and the range is still large in groups of men with the same stature. Thus, men of light weight and spare physique exist at one end of the distribution, and at the other are heavy men of stout physique. It is obvious from this that tables giving the values of mean weight for various statures have only a limited use, and that for many purposes, for example when assessing over- or under-weight in clinical practice, tables of centile values will be of more practical use. Estimates of the 1st, 50th, and 99th centiles of body-weight have been prepared for each stature group from the data (see Table III and Fig. 1). The range, expressed in lb., between the 1st and the 50th centiles is less than that between the 50th and the 99th centiles in each stature group. For example, the ranges are 22·5 and 28·4 lb. respectively for men with statures between 57 and 59 in., and 36·2 and 44·5 lb. respectively for men with statures of 73 to 74·9 in.

The bivariate frequency distribution provides a firm and objective basis for classifying the physique of men into similar groups and estimating the frequency with which the men in each group exist in the population. In the scheme given in Table III, as a matter of convenience, each group has a range of 2 in. stature and about 18 lb. body-weight.

Observation shows that measurements of girths and widths of the body vary amongst men with similar statures and weights, and there is little doubt that further investigation will show this variation to be attributable to differences in the amount or form of the subcutaneous, muscular, and bony tissues. The parallel with somatotyping (Sheldon, 1940) is evident.

Apparently men near the 1st centile limit of the distribution for weight comprise the various groups which are rated in Sheldon's classification as low in mesomorphy and endomorphy, whereas those near the 99th centile limit have high ratings. This latter group of men, as has been observed earlier, probably includes most of the individuals who experience a large increase in body-weight as they become older.

Summary

(1) Statistics on body-weight have been derived from a sample of records of the medical examinations of Scotsmen made in 1941 on being called up for national service.

(2) The distribution of body-weight recorded as the logarithm of the measurement in lb. may be regarded as Normally distributed. This implies that for many purposes body-weight is more satisfactorily recorded on this scale than in lb. avoirdupois.

(3) Body-weight is related to stature by the regression:

Log-weight (log lb.) = 0·0122 Stature (in.) + 1·323.

(4) The mean weights of men by age groups show an upward trend until age 30. After age 30 the trend is very small.

(5) The material has been standardized for differences in stature and age, and it has been found that:

(*a*) The mean weights in the different social classes do not differ significantly.

(*b*) The mean weight of fit men is 4 lb. more than that of unfit men.

(*c*) The mean weights of some occupational orders differ both in Social Classes 1.2 and in Social Class 4.

(*d*) The mean weight of conscripts does not differ from that of volunteers.

(6) The variation in weight associated with geographical factors is limited and confirms the conclusions reached from the study of the measurement of stature.

We gratefully acknowledge the receipt of a grant from the Medical Research Council. We are also most grateful to Professor S. Zuckerman and Mr. M. J. R. Healy for many helpful discussions.

REFERENCES

Bartlett, M. S. (1937). *J. roy. statist. Soc.*, Suppl. **4**, 137.
British Association (1884). "Report of the 53rd Meeting of the British Association for the Advancement of Science, 1883", p. 253.
Clements, E. M. B., and Pickett, K. G. (1952). *British Journal of Social Medicine*, **6**, 245.
Draper, G. (1924). "The Human Constitution". Saunders, Philadelphia.
Fisk, E. L. (1923). "Health Building and Life Extension". Macmillan, New York.
Kemsley, W. F. F. (1950). *Ann. Eugen. (Lond.)*, **15**, 161.
—— (1952). *Ibid.*, **16**, 316.
Martin, W. J. (1949). "Physique of Young Adult Males", M.R.C. Mem. No. 20. H.M.S.O., London.
Medico-Actuarial Mortality Investigation (1912). Association of Life Insurance Medical Directors Actuarial Society of America, New York.
Morant, G. M. (1946). "Flying Personnel Research Committee Report" No. 653. *Quoted by* Kemsley (1952).
Naccarati, S. (1921). "The Morphologic Aspect of Intelligence", *Arch. Psychol., (N.Y.)*, **27**, No. 2 [No. 45].
Newman, R. W. (1952). "Environmental Protection Branch Report No. 194", Office of the Quartermaster General, U.S. Army.
Sheldon, W. H., Stevens, S. S., and Tucker, W. B. (1940). "The Varieties of Human Physique". Harper, New York.
Shuttleworth, F. K. (1937). "Sexual maturation and the physical growth of girls age six to nineteen". *Monogr. Soc. Res. Child Developm.*, **2**, No. 5 (Ser. No. 12).
Snedecor, G. W. (1946). "Statistical Methods", p. 174. Iowa State College Press.
Yuan, P. T. (1933). *Ann. Math. Statist.*, **4**, 30.

Brit. J. prev. soc. Med. (1954), **8**, 108–116

CHEST GIRTH OF MEN RELATED TO STATURE, AGE, BODY-WEIGHT, AND SOCIAL STATUS

CHEST GIRTH OF SCOTSMEN MEASURED IN 1941

BY

E. M. B. CLEMENTS and KATHLEEN G. PICKETT

From the Department of Anatomy, University of Birmingham

Introduction

The relative growth of parts of the body has attracted considerable attention. It reflects the activity of fundamental biological processes (Thompson, 1917; Huxley, 1932); it underlies the various rules of proportion defined in the field of art (Dürer, 1528); it is the basis of all the schemes put forward at one time or another for classifying men and women into constitutional types (Kretschmer, 1925; Sheldon, Stevens, and Tucker, 1940); to-day endocrinologists and nutritionists regard unusual relationships in growth as important physical signs in several clinical conditions. It is not surprising, therefore, that a variety of anthropometric measurements has accumulated over the years. On the other hand, many of the results are presented in the form of indices, and because these are now recognized to be in many ways unsatisfactory forms of presentation (Tanner, 1949), only the results of some recent surveys are readily available for study.

The analyses of Morant (1945) and O'Brien, Girshik, and Hunt (1941) show that measurements of body length are highly correlated. On the other hand, although measurements of body girth and weight are also correlated, the relationships are complex and have not been fully defined. The purpose of this paper is to discuss the relationship of chest girth (a typical measurement of body girth) to body-weight, stature, age, and socio-economic factors. The data used in this study are those for Scotsmen recorded in 1941 during the medical examinations made before national service, because these records are readily available, and are already the basis of earlier studies of stature and body-weight (Clements and Pickett, 1952, 1954).

Technique of Measuring

The medical boards were instructed to measure chest girth by the following technique:

> The man must stand erect during the measurement of the chest, with his feet together and his arms raised above his head. The tape is then so adjusted that its upper border touches the lower angles of the scapulae behind and its lower border the nipples in front. The arms are then lowered slowly to the sides, the tape being retained in position, and the girth is noted after both extreme expiration and extreme inspiration.

The mean of the measurement of chest girth recorded at extreme inspiration and expiration has been taken as the measurement of chest girth throughout this analysis.

No information exists on the extent of the "observer error" of measurements between medical boards, but measurements of chest girth are known to be subject to variations in technique (Davenport, Steggerda, and Drager, 1934). The mean chest girths of men measured by each board are statistically heterogeneous when examined within the same region and social class, and this may indicate a variation in technique from board to board. On the other hand, reasonably consistent mean chest girths are obtained when the data from the medical boards are pooled and sorted into a large number of groups according to stature and weight (Table VI).

Measurements made to fractions of an inch were converted to the first place of decimals ($\frac{1}{4}$ in. being taken down to 0·2 in. and $\frac{3}{4}$ in. up to 0·8 in. to eliminate bias). A frequency distribution shows that whole numbers are most favoured, followed by measurements of $\frac{1}{2}$ in., $\frac{1}{4}$ in., and $\frac{3}{4}$ in. in that order. Measurements were rarely recorded to eighths of an inch.

Results of the Analysis

The mean chest girth for the whole sample of 3,692 records is 34·78 ± 0·03 in. Table I gives the mean chest girth for each region by age groups. The mean chest girth increases with age in every region, but within the same age group the variation is small between geographical regions, although the means of the samples from the Northern Region are consistently the largest. The mean stature and weight of these men were also found in the previous studies to be greater than those of any other regional sample. Table I takes no account of possible differences between the various socio-economic groups of men in the sample, and so the records have been separated into the social classes of the Registrar-General according to the men's stated occupation. Further, the samples from a few small geographical areas, termed "separate" areas, where the mean stature differed significantly from that of the region, have been excluded. The samples for each social class may thus be regarded as homogeneous for socio-economic status and for measurements of stature. Table II gives the mean chest girths of the samples of men according to region and social class. The mean chest girth of the men in Class 1.2 is significantly greater ($P < 0{\cdot}01$) than the means of either Class 3 or Class 4, but the difference between Class 1.2 and Class 5 is not significant. The distribution of the measurements of chest girth and the relationship of this measurement to the other variables have been determined for each of the samples in turn.

Distribution of Measurements of Chest Girth.—The character of the distribution of measurements of chest girth was determined by the method described by Snedecor (1946). A significant skewness exists in three out of four samples, and two of the four samples show a significant kurtosis. The data were transformed into logarithms to base 10, and re-tested. The statistic indicating skewness was no longer significant in three out of four of the samples, although little improvement in the degree of kurtosis resulted from the transformation. The mean chest girth in inches derived from an analysis of the data using the logarithmic scale is 34·71 in. The arithmetical mean of the untransformed data is 34·77 in. and the median value 34·51 in. Clearly, the transformation has very little effect on the value of the mean of the distribution.

A comparison of the observed figures after transformation with the calculated frequencies assuming a normal distribution shows that the distribution is not normal ($\chi^2 = 77{\cdot}6$ *d.f.* 16). There were no obvious discrepancies in either tails of the distribution, and most of the deviations from

TABLE I

MEAN CHEST GIRTH (in.) FOR REGIONS BY AGE GROUPS (UNSTANDARDIZED)

Region	Age Group (yrs)				All Ages
	17–19	20–29	30–39	40–42	
Southern	34·19 ± 0·16	34·81 ± 0·15	35·23 ± 0·22	(1)	34·76 ± 0·11
West Central	34·22 ± 0·10	34·55 ± 0·10	34·86 ± 0·11	34·41 ± 0·56	34·54 ± 0·06
East Central	34·18 ± 0·11	34·84 ± 0·11	35·02 ± 0·11	—	34·71 ± 0·06
Northern	34·24 ± 0·10	35·02 ± 0·10	35·43 ± 0·09	36·02 ± 0·43	35·04 ± 0·06
Total	34·21 ± 0·06	34·80 ± 0·06	35·18 ± 0·06	35·50 ± 0·36	34·78 ± 0·03

TABLE II

MEAN CHEST GIRTH (in.) FOR REGIONS BY SOCIAL CLASS

Region	Class 1 and 2	Class 3	Class 4	Class 5
Southern	34·78 ± 0·43 (28)	—	34·70 ± 0·21 (85)	—
West Central	34·84 ± 0·20 (105)	34·52 ± 0·08 (542)	34·41 ± 0·15 (188)	34·64 ± 0·14 (174)
East Central	34·97 ± 0·25 (77)	34·52 ± 0·08 (455)	34·74 ± 0·17 (136)	35·00 ± 0·13 (227)
Northern	35·53 ± 0·22 (129)	34·84 ± 0·09 (464)	35·01 ± 0·17 (163)	35·09 ± 0·11 (319)
Total	35·13 ± 0·12 (339)	34·65 ± 0·04 (1,461)	34·70 ± 0·09 (572)	34·95 ± 0·07 (720)

expected frequencies occur in four groups in the centre of the distribution. The frequencies of these groups are alternately greater and less than expected. Transformations of the form log (chest measurement ± constant), where the constant was given arbitrary values varying between 5 and 50, were tried and gave no better results than simply taking the logarithm (to base 10) of the measurement. All the remaining analyses in this paper have been made with the data on chest girth measured on the transformed scale, and referred to as "log chest girth".

The relationship between the mean values may be expressed as follows:

Mean Chest Girth (in.) = 0·54 + 0·99 Mean Chest Girth (log in.).

The standard deviation of the whole distribution of chest girth in inches is 2·02 in., or 0·025 log in. when the data are measured on the transformed scale.

RELATIONSHIP OF CHEST GIRTH TO WEIGHT.—Measurements of body-weight have been transformed into the logarithm (to base 10) of the weight in lb. and the transformed measurements are referred to as "log-weight" (Clements and Pickett, 1954). The bivariate distribution of log chest girth and log weight is given in Table III. The measurements of log-weight are, for convenience, grouped in intervals of 0·050 log lb., and those of log chest girth in intervals of 0·020 log in., but the computations have been made on the ungrouped data. Clearly, the variables are highly correlated and the calculated coefficient of correlation is 0·77.

If the relationship between two variables is linear, it may be expressed as a regression equation of the form $y = a + bx$, where x and y are variables, a is a constant, and b is the regression coefficient. The latter statistic indicates the degree of association between the two variables. Curvilinear relationships may be expressed by multiple regression equations which include higher terms of x as additional variables.

Partial regression coefficients relating log chest girth, log-weight, and the square of log-weight, have been computed from the data for the social classes separately, and analysis shows that the coefficients for the separate classes do not differ significantly.[1] On the other hand, the mean log chest girth of the sample of men from each social class differs significantly when weight differences between the samples have been taken into account. These findings indicate that the regressions are parallel and that the coefficients can be pooled, but the constants in the equations will differ according to the social class of the sample.

Further analysis shows that the second degree term (the square of log-weight) is significant and this indicates that the relationship between log chest girth and log-weight is not linear.

The best estimates of the regression coefficients have been derived from the pooled data of the social classes and are:

b_1 (relating to log-Weight) = 0·18 ± 0·01
b_2 (relating to (log-Weight)^2) = 0·043 ± 0·003.

The constant takes the following values:

Class 1.2 + 0·93;
Class 3 + 0·96;
Class 4 + 0·95;
Class 5 + 0·94;
Pooled classes + 0·95.

[1] The 1 per cent. level of probability has been taken to indicate statistical significance throughout this paper.

TABLE III

DISTRIBUTION OF CHEST GIRTH (log in.) AND BODY-WEIGHT (log lb.)

Log Chest Girth	Log-Weight									
	1·900–1·949	1·950–1·999	2·000–2·049	2·050–2·099	2·100–2·149	2·150–2·199	2·200–2·249	2·250–2·299	2·300–2·349	2·350–2·399
1·640–1·659 ..	—	—	—	—	—	—	—	—	1	1
1·620–1·639 ..	—	—	—	—	—	—	—	3	2	1
1·600–1·619 ..	—	—	—	—	1	4	5	10	2	—
1·580–1·599 ..	—	—	—	—	2	32	69	24	1	—
1·560–1·579 ..	—	—	1	10	72	223	131	15	—	—
1·540–1·559 ..	—	—	3	52	405	393	74	2	—	—
1·520–1·539 ..	—	—	33	224	517	166	8	—	—	—
1·500–1·519 ..	—	4	77	214	157	15	—	—	—	—
1·480–1·499 ..	—	6	47	49	12	—	—	—	—	—
1·460–1·479 ..	1	4	11	4	—	2	—	—	—	—
1·440–1·459 ..	1	—	—	—	—	—	—	—	—	—
1·420–1·439 ..	—	—	—	1	—	—	—	—	—	—
99th centile ..	1·4995	1·5171	1·5350	1·5531	1·5714	1·5899	1·6087	1·6277	1·6468	1·6662
Observed mean ..	1·4564	1·4892	1·5066	1·5208	1·5366	1·5528	1·5700	1·5900	1·6217	1·6393
Mean from regressions ..	1·4646	1·4822	1·5001	1·5182	1·5365	1·5550	1·5738	1·5928	1·6119	1·6313
1st centile ..	1·4297	1·4473	1·4652	1·4833	1·5016	1·5201	1·5389	1·5579	1·5770	1·5964

These statistics provide the following relationship:[1]

Chest Girth (log in.) = Constant (depending upon social class) + 0·18 log-Weight (log lb.) + 0·043 (log-Weight)[2].

The observed mean log chest girths and the estimated values derived from the quadratic regression are given for log-weight groups in Table III, and from these it appears that for a unit increase in body-weight (measured in log lb.) the mean log chest girth increases more in the light-weight and heavy-weight groups of men than in the medium-weight groups.

The variances of the distributions of log chest girth within the weight groups are homogeneous according to the test devised by Bartlett (1937). The fact that this distribution is homoscedastic is an additional factor in favour of using the logarithmic rather than the arithmetic scale in analyses of measurements of chest girth.

The 1st and 99th centile limits of chest girth within each weight group have been calculated and are also included in Table III. The results have been transformed into inches, and the regression, 1st and 99th centile lines for chest girth on weight are given in Fig. 1. The values of the 1st centile changed from 26·90 in. for the group of men with a weight of from 80 to 88 lb., to 38·48 in. for the group of men with a weight of 224 to 250 lb., and the values of the 99th centile limit for the same groups are 31·59 in. and 46·37 in. respectively.

[1] The results derived from the linear relationship are very similar in practice: $b = 0·35 \pm 0·01$.

Constant (a) = for	Class 1.2	0·75
	Class 3	0·82
	Class 4	0·79
	Class 5	0·78
	Pooled classes	0·80

Chest Girth (log in.) = Constant (depending upon social class) + 0·35 log-Weight (log lb.).

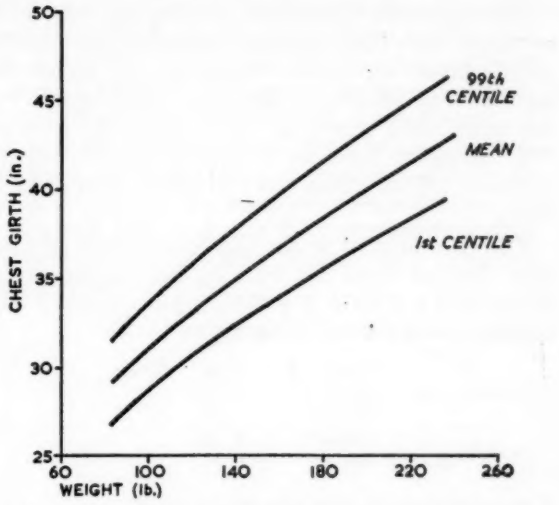

FIG. 1.—Regression, 1st, and 99th centile lines for chest girth on weight Values calculated in log in. and log lb. have been transformed into linear inches, and pounds avoirdupois respectively.

RELATIONSHIP OF CHEST GIRTH TO STATURE.—A bivariate frequency distribution of log chest girth and stature is given in Table IV. Stature has been grouped into intervals with a range of 2 in. in Table IV, but computations have been carried out on the ungrouped data. The correlation coefficient relating the two variables is 0·37. The Table includes the observed mean chest girth for each stature group, together with the estimated mean values derived from linear regression. The observed and estimated values agree well, although there is some suggestion that the rate of increase in log chest girth is less than expected in tall men. Analysis does not confirm this impression, and the relationship is shown to be linear.

TABLE IV

DISTRIBUTION OF CHEST GIRTH (log in.) AND STATURE (in.)

Log Chest Girth	Stature									
	57–58·9	59–60·9	61–62·9	63–64·9	65–66·9	67–68·9	69–70·9	71–72·9	73–74·9	75–76·9
1·640–1·659 ..	—	—	—	—	—	—	—	1	1	—
1·620–1·639 ..	—	—	—	—	—	—	5	1	—	—
1·600–1·619 ..	—	—	—	4	6	7	2	2	1	—
1·580–1·599 ..	—	—	1	9	21	47	32	13	4	1
1·560–1·579 ..	1	—	5	41	115	135	103	44	8	—
1·540–1·559 ..	—	2	33	126	243	288	172	49	16	—
1·520–1·539 ..	3	11	52	164	308	262	112	31	5	—
1·500–1·519 ..	1	8	47	117	150	102	35	6	1	—
1·480–1·499 ..	—	7	23	30	38	11	4	1	—	—
1·460–1·479 ..	1	1	6	6	6	2	—	—	—	—
1·440–1·459 ..	1	—	—	—	—	—	—	—	—	—
1·420–1·439 ..	—	—	—	—	—	1	—	—	—	—
99th centile ..	1·5650	1·5718	1·5785	1·5853	1·5920	1·5987	1·6055	1·6122	1·6189	1·6257
Observed mean ..	1·5130	1·5138	1·5221	1·5324	1·5373	1·5441	1·5507	1·5567	1·5590	1·5855
Mean from regressions ..	1·5108	1·5176	1·5243	1·5311	1·5378	1·5445	1·5513	1·5580	1·5647	1·5715
1st centile ..	1·4567	1·4635	1·4702	1·4770	1·4837	1·4904	1·4972	1·5039	1·5106	1·5174

The regression coefficients relating log chest girth to stature have been calculated from the data for the social classes separately. Analysis shows that the regression coefficients do not differ significantly, but the mean chest girths for each social class do so. The regression lines are therefore parallel but the constants of the equations will differ from class to class.

The best estimate of the regression coefficient has been derived from the data for the pooled social classes and is 0·0034 ± 0·0002 log inches/inch. The constant takes the following values:

Class 1.2 + 1·32;
Class 3 + 1·33;
Class 4 + 1·28;
Class 5 + 1·30;
Pooled classes + 1·32.

These statistics provide the relationship:

Chest Girth (log in.) = Constant (depending upon Social Class) + 0·0034 Stature (in.).

The variances of the distributions of log chest girth within stature groups having a range of 2 in. are not homogeneous. An inspection of the variances suggests that this finding is attributable to unduly large values in the tallest and in the two shortest groups. These three groups also have the fewest number of observations, and in these circumstances the heterogeneity has been disregarded and the variance for the whole sample taken as the best estimate. The 1st and the 99th centile limits of the distribution of log chest girth in each stature group have been derived from the regression relationship and are given in Table IV. These results have been transformed into inches, and the regression, 1st and 99th centile lines for chest girth on stature are given in Fig. 2.

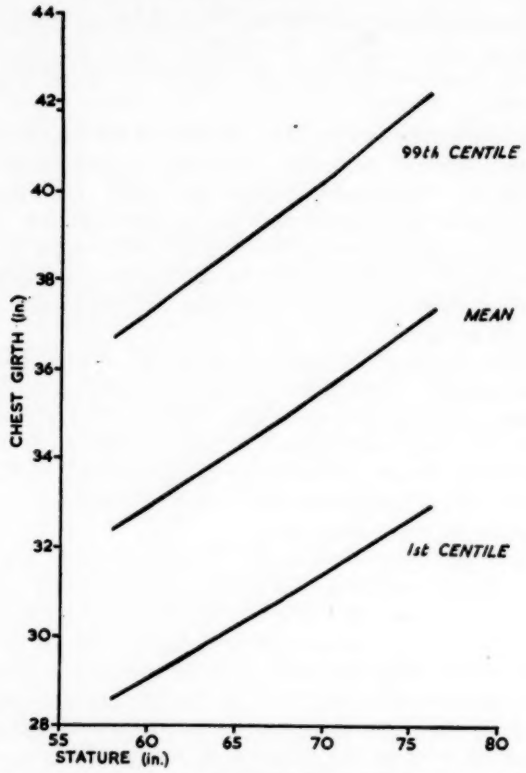

FIG. 2.—Regression, 1st, and 99th centile lines for chest girth on stature.

RELATIONSHIP OF LOG CHEST GIRTH TO AGE.—A bivariate frequency distribution between log chest girth and age is given in Table V. The age groups used in Table V have a span of 2 years, but the statistics have been computed from the data grouped by intervals of one year. A small correlation exists and the calculated coefficient is 0·19. The mean values show a definite trend. Clearly, the mean chest

TABLE V

DISTRIBUTION OF CHEST GIRTH (log in.) AND AGE (yrs)

Log Chest Girth	Age													
	17	18–19	20–21	22–23	24–25	26–27	28–29	30–31	32–33	34–35	36–37	38–39	40–41	42–
1·640–1·659 ..	—	—	—	—	—	—	—	—	—	1	1	—	—	—
1·620–1·639 ..	—	—	1	—	—	—	—	—	1	—	4	—	—	—
1·600–1·619 ..	—	—	5	—	—	1	—	2	4	1	8	—	—	1
1·580–1·599 ..	—	13	9	3	3	10	16	9	8	17	35	5	—	—
1·560–1·579 ..	—	91	56	5	17	27	33	54	24	44	90	6	5	—
1·540–1·559 ..	—	239	178	4	26	49	63	63	57	69	154	18	9	—
1·520–1·539 ..	1	291	189	11	19	52	43	66	44	49	161	16	6	—
1·500–1·519 ..	1	184	111	3	3	14	18	15	19	21	67	6	5	—
1·480–1·499 ..	1	40	30	—	—	5	—	5	2	8	16	5	2	—
1·460–1·479 ..	—	11	6	—	—	2	—	1	—	—	2	—	—	—
1·440–1·459 ..	—	—	—	—	—	—	—	—	—	—	1	—	—	—
1·420–1·439 ..	—	1	—	—	—	—	—	—	—	—	—	—	—	—
99th centile ..	1·5815	1·5872	1·5922	1·5965	1·5999	1·6025	1·6043	1·6054	1·6057	1·6052	1·6039	1·6017	1·5989	1·5952
Observed mean ..	1·5126	1·5339	1·5358	1·5446	1·5493	1·5438	1·5488	1·5473	1·5458	1·5468	1·5447	1·5398	1·5380	1·6031
Mean from regressions ..	1·5289	1·5340	1·5382	1·5417	1·5443	1·5462	1·5473	1·5476	1·5471	1·5459	1·5438	1·5409	1·5373	1·5329
1st centile ..	1·4764	1·4807	1·4842	1·4869	1·4888	1·4899	1·4903	1·4898	1·4886	1·4866	1·4837	1·4801	1·4757	1·4706

girth increases up to about the age of 30 years, after which the mean measurements slowly decline.

The regression coefficients relating log chest girth to age have been calculated from the data for the social classes separately. Analysis confirms that the second degree term is significant and so the data have been fitted by a quadratic regression. Tests show that the regression coefficients are not significantly different in the social classes, but the mean chest girths for each age group differ significantly. It may be concluded that the regression lines are parallel, in which case the estimates of the coefficients may be pooled, but the constants of the equations will differ from class to class. The estimated values of the regression coefficients for the quadratic relationships are:

b_1 (relating to Age) $= 0{\cdot}0061 \pm 0{\cdot}0008$
b_2 (relating to $(\text{Age})^2$) $= -0{\cdot}000099 \pm 0{\cdot}000014$.

The constant takes the following values:

Class 1.2 + 1·46;
Class 3 + 1·46;
Class 4 + 1·45;
Class 5 + 1·44;
Pooled classes + 1·45.

These statistics provide the relationship:

Chest Girth (log in.) = Constant (depending on social class) + 0·0061 Age (yrs) − 0·000099 $(\text{Age})^2$.

The mean chest girth of each age group derived from the quadratic relationship is given in Table V, and the values compare well over the complete range of ages with the observed mean chest girth.

The variance of the log chest girth distribution is not homogeneous. The variance increases from 0·000530 log in. in men aged 18 years up to 0·000805 log in. in men aged 38–39 years.[1] The observed variances have been smoothed by fitting a linear regression. The resulting smoothed values have been used to provide estimates of the 1st and 99th centile limits of chest girth in each age group (Table V). The results have been transformed into inches, and the regression, 1st and 99th centile lines for chest girth on age are given in Fig. 3. It is difficult to define the trend of the 99th centile with age because, although the variance increases, the mean decreases. However, the data show that the range of measurements of chest girth between the 1st and the 50th centile is less than that between the 50th and the 99th centile at all ages. The variation also increases with age, the range between the 50th and the 99th centile increasing from 4·46 in. for men aged 18 years to 5·22 in. for those aged 38–39 years.

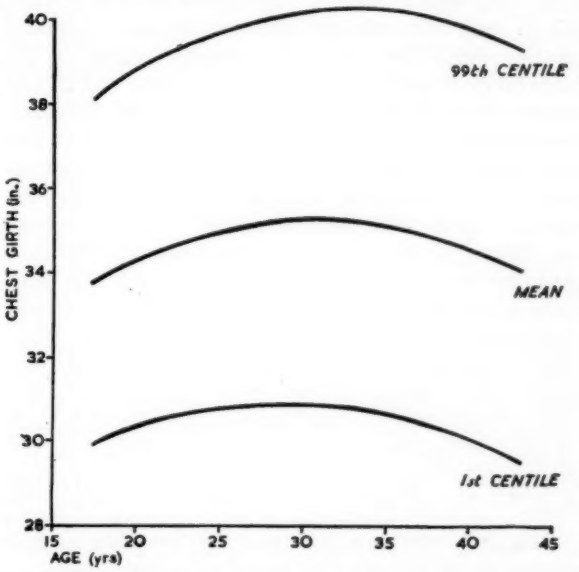

FIG. 3.—Regression, 1st, and 99th centile lines for chest girth on age.

RELATIONSHIP OF LOG CHEST GIRTH TO STATURE AND LOG-WEIGHT:—The data have been separated into groups according to the measurements of stature and body-weight. Each group has a range of stature limited to 2 in. and a range of weight limited to 0·05 log lb. Thus the men in each group have approximately the same stature and weight. The distribution of log chest girth has been examined within each group with six or more observations, and

[1] The last large sample available.

TABLE VI

MEAN CHEST GIRTH (log in.) OF MEN BY STATURE (in.) AND WEIGHT (log. lb.)

Log-Weight	Stature									
	57–58·9	59–60·9	61–62·9	63–64·9	65–66·9	67–68·9	69–70·9	71–72·9	73–74·9	75–76·9
2·250–2·299 ..	—	—	—	—	1·5988	1·5975	1·5906	1·5773	—	—
2·200–2·249 ..	—	—	—	1·5900	1·5727	1·5730	1·5670	1·5670	1·5627*	—
2·150–2·199 ..	—	—	1·5460	1·5595	1·5538	1·5527	1·5511	1·5525	1·5370	—
2·100–2·149 ..	—	—	1·5434	1·5400	1·5360	1·5358	1·5351	1·5256	1·5399	—
2·050–2·099 ..	—	1·5164	1·5250	1·5212	1·5190	1·5211	1·5206	—	—	—
2·000–2·049 ..	—	1·5109	1·5047	1·5061	1·5044	1·5090	—	—	—	—
1·950–1·999 ..	—	—	1·4793	—	—	—	—	—	—	—

the mean log chest girths of the groups of men are given in Table VI. Reading the entries vertically, each column shows a steady increase in mean chest girth associated with increase in weight within each stature group. Reading the Table horizontally, each row shows the mean log chest girth tends to fall slightly with increasing stature in the same weight group.

The estimates of the standard deviations made for each group are very similar, with two exceptions probably attributable to sampling variation, and they have been averaged. The mean value is 0·0165 log in., and this estimate has been used as a measure of the variability in each sample. Clearly, the variability is considerable, and the upper end of the distribution of chest girth in one group overlaps considerably the lower end of the distribution in the next largest group, and so on. Trends in measurements of chest girth associated with changes in stature and body-weight may be expressed quantitatively by the partial regression coefficients derived from a multivariate analysis, and these have been calculated from the data for the social classes separately. Analysis shows that the coefficients for each class do not differ significantly but that the mean chest girths do so after standardizing for differences in stature and log-weight. The estimates of the coefficients may be pooled therefore, but the constants of the equations will differ from class to class.

The best estimates of the coefficients have been derived from the data for the pooled social classes:

The partial regression coefficient relating log chest girth and log-weight, keeping stature constant, is $b_{y1\cdot 2} + 0{\cdot}38 \pm 0{\cdot}01$*.

The partial regression coefficient relating log chest girth and stature, keeping log-weight constant, is $b_{y1\cdot 2} - 0{\cdot}0012 \pm 0{\cdot}0001$*.

The constant of the equation is:

Class 1.2	+ 0·79;
Class 3	+ 0·83;
Class 4	+ 0·79;
Class 5	+ 0·79;
Pooled classes	+ 0·80.

These statistics taken together establish the following relationship:

Log Chest Girth = Constant (depending upon social class) + 0·38 log-Weight − 0·0012 Stature (in.).

The partial regression coefficients indicate that chest girth increases at the rate of 0·38 log in. for each unit increase in weight expressed as log lb. in men with the same stature but with different weights. On the other hand, chest girth decreases at the rate of 0·0012 log in. for each unit increase in stature amongst men of the same weight but varying stature.

Relationship of Log Chest Girth to Stature, Log-Weight, and Age.—The relationship of log chest girth to the variables of stature, log-weight, and age taken together requires consideration. The technique of multivariate analysis, employed in the previous section to study variations associated with weight and stature, may be extended to include age as an extra variable. The partial regression coefficients of stature, weight, and age have been derived from the data for the pooled social classes, and all the coefficients are significant. An analysis of the data for Social Class 3 indicates that the second degree term for weight is significant, but this term has not been taken into account in the analyses of the main samples. The second degree term of age is not significant when the variables of stature and weight are taken into account.

The partial regression coefficient relating log chest girth and log-weight, keeping stature and age constant, is

$$b_{y1\cdot 23} = 0{\cdot}37 \pm 0{\cdot}01^{*}.$$

The partial regression coefficient relating log chest girth and stature, keeping log-weight and age constant, is

$$b_{y2\cdot 13} = +\,0{\cdot}00034 \pm 0{\cdot}00004^{*}.$$

The partial regression coefficient relating log chest girth and age, keeping log-weight and stature constant, is

$$b_{y3\cdot 12} = -\,0{\cdot}00097 \pm 0{\cdot}00013^{*}.$$

These statistics taken together establish the following relationship:

Chest Girth (log in.) = 0·80 + 0·37 log-Weight (log lb.) + 0·00034 Age (yrs) − 0·00097 Stature (in.).

The multiple coefficient of correlation $R = 0{\cdot}80$.

The partial regression coefficients given in the above equation express quantitatively the changes in chest girth attributable to each unit increase in the variables of weight, age, and stature.

Geographical Variation.—Table II presents the mean chest girths of men for the regions and the social classes defined by the Registrar-General. As has already been observed, the largest mean chest girth in each social class occurs in the sample from the Northern Region. Such a finding in unstandardized data may simply reflect the geographical variation already determined from measurements of stature and weight, because chest girth is correlated with these variables. On the other hand, chest girth may vary independently of the other measurements. Before the facts can be established, the data on chest girth must be standardized so as to take into account

* Where y represents the variable of log chest girth.
x_1 represents the variable of log weight.
x_2 represents the variable of stature.
x_3 represents the variable of age.

differences in the other known variables. In this analysis, tests of significance have been made by a covariance analysis taking stature, weight, and age into account. The examination shows that a general heterogeneity exists and that no homogeneous samples can be provided for the social classes by separating out areas with unusual chest girths. The actual extent of the difference between the means is very small, but the statistical tests are sufficiently sensitive, after carrying out the standardizing procedures, to differentiate one medical board from another within the same region. The finding may reflect a genuine variation from area to area; on the other hand the finding may represent a variation in the measuring technique between the boards. Clearly, the technique of measuring girths of the body must be rigorously standardized before differences between samples can be regarded seriously as indicating definite geographical variation.

SOCIAL CLASS.—The heterogeneity of the samples for geographical factors can be disregarded when examining the significance of differences between the social classes, if the assumption is justified that each medical board contributes a similar proportion of men to the different groups under examination. The distribution of men in the different social classes in the medical boards is not seriously heterogeneous, and a comparison between them is justified. The unstandardized mean values of the chest girth of men by region and social class are given in Table II. The mean values of the chest girth after being transformed into inches and standardized for stature 67 in., weight 2·1399 log lb. (138 lb.), and age 26 yrs, are as follows:

Social Class	*Standardized Mean Chest Girth (in.)*
1.2	34·71
3	34·79
4	34·80
5	34·81

$P > 0{\cdot}01$

The mean measurements are all very similar and the differences are not significant. All the previous tests showed that the mean chest girths of men in various social classes differed significantly, but in these tests only one variable was standardized at a time, and in one other case two variables (log-weight and stature) were taken together. Clearly, if age is included with stature and weight, and the data are standardized, separation of data into social classes is unnecessary.

DIFFERENCES BETWEEN MEN CLASSED AS FIT AND UNFIT FOR MILITARY SERVICE.—Assuming that the proportion of fit to unfit men is much the same in each medical board, and in this way disregarding the heterogeneity of the samples for the geographical factor, analysis shows that fit men have a greater chest girth than unfit men, although the actual difference is very small in amount. The standardized mean chest girth in inches after conversion from the transformed data is:

Class	*Mean Chest Girth (in.)*
Fit	34·85
Unfit	34·64
Unclassified	34·97

$P < 0{\cdot}01$

DISCUSSION

A considerable variation exists in measurements of chest girth in men with similar statures and body-weights. For example, in the group of men with a stature of from 63 to 64·9 in. and a weight of from 2·05 to 2·09 log lb. (112–124 lb.), 10 per cent. have a chest girth of 31·6 in. or less, and 10 per cent. a chest girth of 34·9 in. or more. The chest girth of 55·6 per cent. of individuals in the next heaviest group, men weighing from 2·10 to 2·14 log lb. (125–139 lb.), in the same stature group, is less than 34·9 in.

How much of the variance existing in the measurement of chest girth is attributable to constitutional factors, and how much to variations in nutrition is not known, but frequently these two factors are confused. Sometimes anthropometric measurements, such as, for example, the relationship of weight and stature, are employed as indices of nutrition, and at other times as a means of classifying men into physical types.

Sheldon, Stevens, and Tucker (1940) employed the ratio of chest girth to stature to distinguish between their factors of mesomorphy (muscle) and endomorphy (body fat), and found that men with a high factor of endomorphy tended to have the higher index. It may therefore be supposed that men with a larger chest girth for the same weight have a higher factor of endomorphy than men with smaller chest girths. It was noted earlier that the mean chest girth increases more rapidly in both light-weight and heavy-weight groups than in the medium-weight groups. This observation may indicate that the changes in weight at either end of the weight distribution are mainly associated with changes in the fatty tissue.

The separation of men into groups each comprising men with much the same stature and weight (such, for example, as the groups in Table VI) provides a convenient framework within which to study body constitution. Variations in human physique have been studied recently by means of factor analysis (Burt and Banks, 1947; Hammond, 1942) and a general factor for size was defined first. The regression line relating stature and log weight indicates that, on the average, an increase in stature is accompanied by an increase in weight. Bigness in one dimension is associated with bigness in another. In other words, the regression has much the same biological interpretation as the general factor, and both express the principle of isogonic growth (Huxley, 1932). The variance from the regression line relating log weight and stature distinguishes between men of spare and stout physique, and the first bipolar factor defined by factor analysis achieves the same object. The second factor, according to Burt and Banks, separates measurements of girth into two groups; in their analysis, abdomen and hip girths were separated from shoulder girth and weight. The variance of chest girth within the groups of equal stature and weight may possibly be related to this factor.

The regression coefficients of chest girth on weight determined for men in the various social classes in Scotland do not differ significantly, and the same stability of coefficients is found in those relating chest girth to stature to stature and age respectively. There can be little doubt that most regression coefficients relating anthropometric measurements do not vary within a wide range of conditions. This stability is of considerable practical importance, because when once a relationship has been established it can be applied confidently to other sections of the same community. On the other hand the factors which may be associated with different regression relationships will be of great biological interest.

SUMMARY

(1) Statistics on the chest girth of men living in Scotland have been derived from a sample of records of the medical examinations made by the Ministry of Labour and National Service in 1941.

(2) Measurements of chest girth have a skew distribution, but a more satisfactory distribution for analysis is obtained by transforming the measurements into logarithms to base 10.

(3) Chest girth is related to other variables by the following regression equations:*

(*a*) To Weight:
Log Chest Girth = 0·80 + 0·35 log-Weight
(or more accurately) = 0·95 + 0·18 log-Weight + 0·043 (log-Weight)^2.

(*b*) To Stature:
Log Chest Girth = 1·32 + 0·0034 Stature.

(*c*) To Age:
Log Chest Girth = 1·45 + 0·0061 Age − 0·000099 (Age)^2.

(*d*) To Weight, Stature, and Age together:
Log Chest Girth = 0·80 + 0·37 log-Weight − 0·00097 Stature + 0·00034 Age.

(4) The mean chest girths of men by age groups show an upward trend until about 30 years of age, which is succeeded by a slow downward trend.

(5) The material has been standardized for differences in stature, weight, and age, and the following facts have been established:

(*a*) In the samples for each social class, the mean chest girths of men measured by different medical boards differ significantly. Whether the finding should be attributed to differences in measuring technique or to real geographical differences is not known.

(*b*) The mean chest girths of men in different social classes do not differ significantly.

(*c*) The mean chest girth of the sample of fit men is 0·21 in. greater than that of unfit men.

We gratefully acknowledge the receipt of a grant from the Medical Research Council. We are also most grateful to Prof. S. Zuckerman and Mr. M. J. R. Healy for many helpful discussions.

REFERENCES

Bartlett, M. S. (1937). *J. roy. statist. Soc.*, Suppl. **4**, 137.
Burt, C., and Banks, C. (1947). *Ann. Eugen. (Camb.)*, **13**, 238.
Clements, E. M. B., and Pickett, K. G. (1952). *British Journal of Social Medicine*, **6**, 245.
—— —— (1954). *Ibid.*, **8**, 99.
Davenport, C. B., Steggerda, M., and Drager, W. (1934). *Proc. Amer. Acad. Arts Sci.*, **69**, 265.
Dürer, A. (1528). "Vier Bücher von menschlicher Proportion." Hieronymus Andreae, Nuremberg.
Hammond, W. H. (1942). *Man.*, **42** (No. 3), 4.
Huxley, J. (1932). "Problems of Relative Growth." Methuen, London.
Kretschmer, E. (1925). "Physique and Character". Kegan Paul, London.
Morant, G. M. (1945). Flying Personnel Research Committee Report, No. 633a.
O'Brien, R., Girshik, M. A., and Hunt, E. P. (1941). U.S. Department of Agriculture Miscellaneous Publication, No. 366.
Sheldon, W. H., Stevens, S. S., and Tucker, W. B. (1940). "The Varieties of Human Physique." Harper, New York.
Snedecor, G. W. (1946). "Statistical Methods", p. 174. Iowa State College Press.
Tanner, J. M. (1949). *J. appl. Physiol.*, **2**, 1.
Thompson, D'A. W. (1917). "On Growth and Form." University Press, Cambridge.

* Log Chest Girth is measured in log in.
Log-Weight is measured in log lb.
Stature is measured in linear inches.
Age is measured in years.

Brit. J. prev. soc. Med. (1954), **8**, 117–123

HETEROSPECIFIC PREGNANCY

BY

J. M. JOHNSTONE

*Department of Pathology, West Middlesex Hospital, Isleworth**

Hirszfeld (1928) was the first to draw attention to the numbers of children of each ABO blood group born of various mating types, and reported fewer Group A children born of A × O matings (56·6 per cent.) than of O × A matings (63·8 per cent.). He later reviewed data gathered between 1927 and 1933 but was unable to confirm his previous findings (Hirszfeld, 1934).

However the position was re-investigated by Waterhouse and Hogben (1947), who pooled the family blood group data of twelve authors and showed that only 56·1 per cent. Group A children were born of A × O matings compared with 61·7 per cent. born of O × A matings. They claimed there to be a deficiency of 25 per cent. of Group A children in A × O matings, which represents a foetal mortality of 8 per cent. of Group A foetus, or about 3 per cent. of all conceptions. To explain this, it was suggested that the anti-A agglutinin of Group O mothers reacted adversely with their Group A foetus to produce early and late foetal deaths.

This same suggestion had been advanced by Levine (1943) in explanation of certain abortions; he claimed that women of heterospecific matings had a higher abortion rate than those of homospecific matings.

This paper presents a further investigation of the problem, the object being to determine whether or not the fact that a mating is heterospecific has any bearing on the number of children of each blood group born of it.

Material

In the period November, 1949, to December, 1950, blood samples were obtained from mothers delivered in this hospital, from their infants, and from the infants' fathers. The ABO and Rh groups of the samples were determined by the tube technique described in Medical Research Council Memoranda No. 9 (1943) and No. 19 (Mollison and others, 1948). Details of previous pregnancies were recorded, but it was not possible to examine any previous children. All live-born infants, irrespective of the period of gestation, were included in this sample; no still-births were included.

There was no deliberate selection of cases, every endeavour being made to secure samples from each mother, father, and child throughout the period of investigation.

Definitions

When the red cells of the father or child possess an antigen which can be agglutinated by the anti-A or anti-B agglutinin of the mother's serum (*i.e.* an antigen not possessed by the mother), the mating or pregnancy is considered heterospecific or incompatible, in contrast with a homospecific or compatible mating or pregnancy in which no such antagonism can exist (Levine, 1943; Table I).

TABLE I

BLOOD GROUPS OF MOTHER, FATHER, AND CHILD IN HOMO- AND HETEROSPECIFIC PREGNANCIES AND MATINGS

Blood Group of Mother	Blood Group of Child		Blood Group of Father	
	Homo-specific	Hetero-specific	Homo-specific	Hetero-specific
O	O	A, B	O	A, B, AB
A	O, A	B, AB	O, A	B, AB
B	O, B	A, AB	O, B	A, AB
AB	A, B, AB	—	O, A, B, AB	—

While the mating Father A × Mother O is classified as heterospecific, not all of the resulting pregnancies are to be so regarded. Should the father be of the genotype AO, half of the children are likely to be of Group O; where this is so the pregnancy is homospecific, but where the child is Group A the pregnancy is heterospecific.

When dealing with the Rh system, only Rh-negative mothers with Rh-positive children and husbands have been considered to be heterospecific pregnancies and matings, as the elementary Rh antigens *c*, *d*, and *e* act as very weak antigens normally.

* Present address: Dept. of Pathology, University and Western Infirmary, Glasgow.

Matings will always be shown with the group of the father first, *i.e.* O×A represents a father of Group O and a mother of Group A.

Results

ABO Matings.—The ABO blood group of 2,578 families (5,156 adults and 2,596 children) was determined, and the gene frequencies of the sample, calculated by Fisher's method (Dobson and Ikin, 1946), are set out in Table II. Comparison of the expected (264) and observed (241) numbers of Group AB persons serves as a check on the randomness of the sample ($\chi^2=1\cdot375$; $P>0\cdot20$ $<0\cdot30$).

Table II

GENE FREQUENCIES OF 5,156 ADULTS AND 2,596 CHILDREN

Gene	Adults	Children	Adults and Children
O	0·67137	0·66576	0·66949
A	0·26589	0·26880	0·26686
B	0·06273	0·06543	0·06364

The expected numbers of children of each blood group born of each mating type were calculated from formulae given by Waterhouse and Hogben (1947); they are compared with the observed numbers in Table III. Seventeen children have blood groups inconsistent with those of their alleged parents. It was not possible to re-examine all of these discrepancies, but where this was done doubt about the alleged father was usually revealed; in accordance with general experience most of these were first pregnancies. In a few instances mislabelling of specimens may have occurred, but great trouble was taken to exclude this by careful checking. Comparison of the expected and observed numbers of children by the χ^2 test show a significant difference between the two figures only in the matings O×A and B×A.

The reciprocal matings O×A and A×O will be considered in detail as they comprise the largest number, and the findings in these types may be compared with those of previous authors.

If, in A×O matings, as suggested by Waterhouse and Hogben (1947), the anti-A agglutinin in the Group O mother's serum is capable of acting lethally, either early or late in pregnancy on any group A foetus which she may carry, then fewer Group A children may be born of these matings than of O×A matings. From Table IV this indeed seems to be the case; this agrees with the reports of Hirszfeld (1928) and of Waterhouse and Hogben (1947) which are given here for comparison. However, when the total numbers, and not merely the

Table IV

PERCENTAGE OF GROUP A CHILDREN BORN OF O×A AND A×O MATINGS

Series	Percentage of Group A Children		Difference
	Mating O×A	Mating A×O	
Present	62·6±1·55	58·2±1·59	4·4±2·19
Hirszfeld (1928) ..	63·8±1·36	56·6±1·36	7·2±1·92
Waterhouse and Hogben (1947)	61·7±1·7	56·1±1·9	5·6±2·54

Table III

OBSERVED AND EXPECTED NUMBERS OF CHILDREN OF EACH GROUP BORN OF EACH MATING TYPE COMPARED, USING THE χ^2 TEST

Mating		Number of Matings	Group of Children								Number of Children	χ^2	Degrees of Freedom	P
			O		A		B		AB					
Father	Mother		Expected	Observed	Expected	Observed	Expected	Observed	Expected	Observed				
O	O	550	555	546	—	8*	—	1*	—	—	555	—	—	—
A	O	471	198	197	276	276	—	1*	—	—	474	0·005	1	0·9
B	O	112	55	59	—	—	60	55	—	—	114	0·711	1	0·5
AB	O	33	—	1*	17	14	17	18	—	1*	34	0·470	1	0·5
O	A	485	203	181	284	305	—	1*	—	—	487	3·904	1	<·05
A	A	500	88	79	416	425	—	—	—	—	504	1·114	1	0·3
B	A	99	20	20	28	20	22	33	30	26	99	8·729	3	<·05
AB	A	32	—	1*	16	16	7	9	9	6	32	1·587	2	0·5
O	B	99	47	48	—	1*	52	50	—	—	99	0·091	1	0·8
A	B	90	18	20	25	18	20	20	28	33	91	3·074	3	0·5
B	B	18	4	1	—	—	14	17	—	—	18	2·892	1	0·1
AB	B	11	—	1*	3	1	6	5	3	4	11	0·733	2	0·7
O	AB	31	—	—	16	15	16	15	—	1*	31	0·000	1	—
A	AB	35	—	—	18	18	7	7	10	10	35	0·000	2	—
B	AB	9	—	—	2	2	5	5	3	2	9	0·155	2	0·9
AB	AB	3	—	—	1	1	1	1	2	1	3	0·999	2	0·7
Total		2,578	1,188	1,154	1,102	1,120	227	238	85	84	2,596	2·142	3	0·5
												$\Sigma\chi^2$	24·564	24	0·5

* Exceptions to Bernstein's law.

TABLE V

EXPECTED AND OBSERVED NUMBERS OF CHILDREN BORN OF O×A AND A×O MATINGS COMPARED, USING χ^2 TEST (EXCEPTIONS TO BERNSTEIN'S LAW EXCLUDED)

Series	Mating		Number of Children	Group of Children				χ^2	*P*
				O		A			
	Father	Mother		Expected	Observed	Expected	Observed		
Present	O	A	487	203	181	284	305	3·904	<0·05
	A	O	474	198	197	276	276	0·005	0·9
Hirszfeld (1928)	O	A	570	236	202	334	364	7·404	<0·01
	A	O	606	251	257	355	343	0·650	0·5
Waterhouse and Hogben (1947)	O	A	835	349	320	486	515	4·139	<0·05
	A	O	686	287	301	399	385	1·173	0·3

TABLE VIA

NUMBER OF CHILDREN OF EACH GROUP IN EACH BIRTH RANK

Mating		Group of Children	Birth Rank of Children											Total
Father	Mother		1	2	3	4	5	6	7	8	9	10	11	
O	A	A	139	104	29	20	6	1	2	2	1	1	—	305
		O	85	58	22	10	4	1	1	—	—	—	—	181
A	O	A	130	100	34	5	3	4	—	—	—	—	—	276
		O	100	66	20	6	2	2	—	—	—	—	1	197

percentages of children born of these matings, are considered (Table III) another aspect of the problem emerges. It is in the heterospecific A×O matings that the expected and observed numbers of children of each group fit most closely, while in the homospecific O×A matings there is a significant deviation, with a deficiency of Group O children, the observed number being actually 22 less than expected.

This is the only mating of any magnitude in the whole sample which shows a significant difference between the expected and observed numbers of children of each blood group.

This finding being unexpected, the data of Hirszfeld (1928) and of Waterhouse and Hogben (1947) were recalculated and similar significant results were obtained in each instance (Table V).

Waterhouse and Hogben (1947) found that the A/O ratio of children born of A×O matings decreased with birth rank, particularly from the third rank onwards, and they presumed that this might be due to an increase in the maternal anti-A titre with repeated heterospecific pregnancies. No such decrease was found in this sample (Table VIA and B), but the total numbers from the third rank onwards are small, and, under present-day conditions, an enormous population sample would require to be tested in order to obtain a satisfactory series and yet avoid selection of appropriate families.

TABLE VIB

A/O RATIO BY BIRTH RANK

Mating		A/O Ratio by Birth Rank		
Father	Mother	1	2	3 and all others
O	A	1·63	1·79	1·63
A	O	1·30	1·51	1·48

In this series very similar figures were obtained for the A/O ratio in each pregnancy rank.

Again, assuming heterospecific pregnancy to be capable of producing an undue proportion of foetal deaths, fewer women in A×O matings would be expected to proceed to term and be delivered of viable infants, than in O×A matings. That this is not so is obvious from Table VII, in which the numbers of mothers delivered of viable infants of the two matings under consideration are shown.

TABLE VII

NUMBERS OF O×A AND A×O MATINGS IN WHICH THE MOTHER WAS DELIVERED OF A LIVE CHILD

Mating		Percentage of all Matings	Number of Matings		χ^2	*P*
Father	Mother		Observed	Expected		
A	O	18·3±1·2	471	478	0·205	0·7
O	A	18·8±1·2	485	478		

Similarly, for the whole sample, there is no significant deficit of women in heterospecific matings successfully delivered of a viable infant (Table VIII).

TABLE VIII
NUMBERS OF HOMO- AND HETEROSPECIFIC MATINGS IN ENTIRE SAMPLE

Mating Type	Total Numbers	Percentage	Percentage expected in a random sample
Homospecific	1,730	67·1	66
Heterospecific	848	32·9	34

Although the O × A and A × O matings are mainly under consideration, any action of the maternal anti-A agglutinin of Group O mothers in A × O matings on Group A foetus might equally well be operative in other heterospecific matings such as AB × O, and in certain A × B and AB × B matings, and the total observed number of Group A children in the sample might be significantly less than the expected number. However, reference to Table III shows that these two figures for the whole sample agree very closely and that no deficit of Group A children does exist in the entire sample.

ABO AND RH MATINGS.—In 1,590 of the 2,578 families already analysed, both the ABO and Rh blood groups were determined, giving a total of 3,180 adults and 1,602 children. The gene frequencies are detailed in Table IX. The expected numbers of children born of each Rh mating type have been calculated and are shown, together with the observed numbers, in Table X. The Rh groups of six children in the mating Rh neg. × Rh neg. fail to fit with that of their parents.

TABLE IX
Rh GENE FREQUENCIES OF THE SAMPLE (3,180 ADULTS, 1,602 CHILDREN)

Gene for	Adults	Children	Adults and Children
Rh positive	0·5682	0·5857	0·5740
Rh negative	0·4318	0·4143	0·4260

Again taking the reciprocal matings O × A and A × O, as they contain the greatest numbers, the expected numbers of children born have been calculated, both the ABO and Rh status of the matings being considered. These figures, together with the observed numbers, are detailed in Table XI (opposite).

No significant deviation is noted between the observed and expected numbers of children born of each mating type, and the sum of χ^2 tests is only 13·256 ($P>0·80<0·90$). Comparison of the observed and expected numbers of children born of these two matings in this sample, considering only the ABO blood groups, showed no significant deviation.

From this one sample it would appear that the Rh status of the parents in O × A and A × O matings has no influence on the numbers of children of Groups O and A born of them, provided that cases of maternal Rh iso-immunization are excluded.

MATINGS RESULTING IN ABORTIONS.—Waterhouse and Hogben (1947), claiming a deficit of Group A children born of A × O matings, thought this due to the action of the maternal anti-A agglutinin causing an excessive number of early and late foetal deaths. A similar view was propounded by Levine (1943) and also by Wiener and others (1949), who found that, in matings in which two or more abortions had occurred, there was an unduly high proportion of heterospecific matings. Race and Sanger (1950) give the figures for each type of mating expected to be found in a normal random sample of the English population as 66 per cent. homospecific and 34 per cent. heterospecific, with very comparable values for an American population. In the present sample, far from there being an excess of heterospecific matings in the group which have had previous abortions, there are actually rather fewer than would be

TABLE X
EXPECTED AND OBSERVED NUMBERS OF CHILDREN OF THE FOUR Rh MATING TYPES

Rh Type		Number of Matings	Children				Total Number of Children	Degrees of Freedom	χ^2	P
			Positive		Negative					
Father	Mother		Expected	Observed	Expected	Observed				
Positive	Negative	230	163	172	70	61	233	1	1·653	0·3
Negative	Positive	245	173	188	75	60	248	1	4·300	<0·05
Positive	Positive	1,056	965	961	97	101	1,062	1	0·181	0·7
Negative	Negative	59	—	6	59	53	59	—	—	—
Total		1,590	1,301	1,327	301	275	1,602	1	2·764	0·1

TABLE XI

EXPECTED AND OBSERVED NUMBERS OF CHILDREN OF EACH ABO AND Rh GROUP BORN OF O × A AND A × O MATINGS

Mating		Number of Matings	Children								Total Number of Children	Degrees of Freedom	χ^2	P
Father	Mother		A Positive		A Negative		O Positive		O Negative					
			Expected	Observed	Expected	Observed	Expected	Observed	Expected	Observed				
O Positive	A Positive	173	92	96	9	7	66	63	7	8	174	3	0·895	0·9
O Negative	A Positive	62	25	31	11	9	18	16	8	6	62	3	2·525	0·5
O Positive	A Negative	54	22	20	10	10	16	17	7	8	55	3	0·386	0·9
O Negative	A Negative	10	—	—	6	8	—	—	4	2	10	1	1·666	0·2
A Positive	O Positive	195	104	101	11	16	74	71	8	8	196	3	3·121	0·5
A Negative	O Positive	44	18	20	8	7	13	12	5	5	44	3	0·424	0·9
A Positive	O Negative	41	17	12	7	8	12	17	5	4	41	3	3·896	0·3
A Negative	O Negative	12	—	—	7	6	—	—	5	6	12	1	0·343	0·7
Total		591	278	280	69	71	199	196	49	47	594	3	0·194	0·9
												$\Sigma\chi^2$	13·256	0·9

expected in a random English population sample. This agrees closely with the data given in the majority of papers dealing with this question (Table XII).

TABLE XII

PERCENTAGE OF HETEROSPECIFIC MATINGS IN WHICH ABORTIONS HAVE OCCURRED

Series	Number of Abortions	Percentage of Matings		Number of Matings
		Homospecific	Heterospecific	
English Random Population ..	—	66	34	—
Levine (1943) ..	2 or more	46	54	115
Wiener, Wexler, and Hurst (1949) ..	2 or more	47	53	89
Race and Sanger (1950)	average of 3	72	28	43
Sjöstedt, Grubb, and Linell (1951) ..	2 or more	64	36	242
Present series ..	2 or more	71	29	48
Present series ..	1 or more	74	26	258

DISCUSSION

Assuming an adverse and probably lethal action on the foetus by the maternal natural agglutinins in heterospecific pregnancies, various effects might be observed:

(*i*) fewer children of Group A might be born of the heterospecific A × O matings than of the homospecific O × A matings;

(*ii*) the A/O ratio of children born of the A × O matings might decrease with birth rank while remaining constant in O × A matings;

(*iii*) fewer women in A × O matings might proceed to term than of O × A matings;

(*iv*) an overall deficit of Group A children might be seen in any population sampled.

Further, in a group of matings in which abortions have occurred, an undue proportion of heterospecific matings might be observed. These points have all been considered in this work but the results of the investigation do not support any of these assumptions.

In a series of 2,000 mothers and their infants analysed by Boorman (1950) there was no significant deficit of Group A children born of Group O mothers compared with the Group O children born of Group O mothers. A similar observation was reported by Bryce and others (1950). Struthers (1951) suggested that, if there is no deficiency of Group A children to be observed at birth but such a deficiency is found in later life, then this may be due to a selective loss of Group A infants and children. He showed that in his four hundred autopsies there was a deficit of Group O infants and children in the group dying with bronchopneumonia, particularly in those below 2 years of age, and he postulated an increased susceptibility of Group A, B, and AB infants and children to pulmonary infection as a late result of heterospecific pregnancy. However, no parental blood group data were available and his ABO determinations were made by the "slide" technique which is prone to give false results, particularly false positives in infective conditions, especially when blood obtained *post mortem* is used.

Kirk and others (1953), examining a West Australian population, suggested that the fertility of Group O women in compatible matings is greater than that of Group O women in incompatible matings and that of Group A women generally.

Allan (1953), in his analysis of the data of Waterhouse and Hogben (1947), found evidence which suggested that the deficit of Group A children of A × O matings was part of a general shortage of children of all Group A fathers, whatever the mating, rather than the result of any action of the maternal anti-A agglutinin, the average number of children of homospecific and heterospecific matings being found to be remarkably close.

Nevertheless, from their data, Waterhouse and Hogben (1947) calculated there to be a deficiency of 25 per cent. of Group A children born of A × O matings, representing a foetal mortality of 8 per cent. in Group A children, approximately 3 per cent. of all conceptions. This is a very large figure and would considerably alter the ABO gene frequencies of a population in a few generations, provided that the population was not otherwise affected by any great numbers of immigrants, and that no other counter-balancing factor operated. The very large blood-donor samples analysed by Hart (1943) and Roberts (1948) show close agreement between every age group and would suggest that the gene frequencies do indeed remain fairly constant.

The figures given in Table XII suggest that, should there be a loss of Group A children of heterospecific matings, it cannot be accounted for by an excessive number of abortions resulting from such matings. This is not an isolated finding but confirms the reports of various other authors (Hirszfeld, 1949; Race and Sanger, 1950; van Loghem and others, 1950; Sjöstedt and others, 1951). Similarly, AB iso-immunization of the mother is unlikely to account for the loss of many infants, as, despite the increasing numbers of instances reported in the literature, notably those of Boorman and others (1949) and Mollison and Cutbush (1949), such well-authenticated cases are uncommon. Of 3,070 deliveries personally examined, none showed unequivocal evidence of AB iso-immunization compared with an incidence for Rh iso-immunization of approximately one in two hundred.

It is true that the percentage of Group A children born of A × O matings is lower than that born of O × A matings, both in the present sample and in the series of Hirszfeld (1928) and Waterhouse and Hogben (1947), but it appears that this consideration of percentage alone has helped to give rise to the view that there is an actual deficit of Group A children of A × O matings. When the observed and expected numbers of children of each blood group born of the reciprocal O × A and A × O matings are studied, no significant difference is seen to exist between the two values for the heterospecific A × O matings in any of the three populations studied (Table V). It is in the homospecific O × A matings that a significant difference is observed between the expected and observed numbers of children of each blood group. Such a difference occurring in one sample alone might well be attributed to chance, but its occurrence in three populations is striking. In each instance this difference appears to arise from a deficit of Group O children of the O × A matings, but it is difficult to give any satisfactory reason to account for this.

Differential fertilization of the ovum is unlikely to be a factor. Waterhouse and Hogben (1947) rightly pointed out that the formulae used for the calculation of the expected numbers of children of each blood group born of each mating type depend for their accuracy on the equal viability of the blood group genes. Reference to Table III shows that the genes do appear to have equal viability and that the formulae used appear to be correct, for in nearly every instance the expected and observed numbers of children agree closely; support is afforded to this by the studies of Hart (1943) and Roberts (1948) already mentioned. Similarly, differential foetal mortality *in utero*, unless occurring very early and being mistaken perhaps for a delayed period, is improbable, and, despite this interesting but inexplicable deficit of Group O children of O × A matings (the only mating of any consequence numerically which shows a significant deviation between the observed and expected numbers of children born) the total numbers of observed and expected children of Groups O and A born of all mating types in this sample show remarkably close agreement.

It is suggested that the belief that there is a significant deficit of Group A children born of A × O matings is erroneous, and that this view has arisen largely from considering the relative percentages of children in each blood group born of each mating type instead of considering absolute numbers, and that there is in fact a deficit of Group O children born of O × A matings. Also it has been shown that, in this sample, the total observed number of children of each group born of all mating types agrees very closely with the expected number. It is believed therefore that the maternal natural agglutinins play a very minor role, if any, in determining the number of children of each blood group to be born of the various mating types in a population.

SUMMARY

(1) Hirszfeld (1928) and Waterhouse and Hogben (1947) found a lower percentage of Group A children born of the heterospecific A × O mating than were born of the homospecific O × A mating. This problem has been investigated in a sample of the West London and West Middlesex population.

(2) The ABO blood groups of 2,578 families (5,156 adults and 2,596 children) were determined.

(3) The percentage of Group A children born of the A × O and O × A matings was 58·2 and 62·6 per cent. respectively.

(4) The expected and observed numbers of children of each group agreed closely in the heterospecific A × O mating, but differed significantly in the homospecific O × A mating. This difference is thought to be due to a deficit of Group O children.

(5) The A/O ratio of children born of the A × O mating did not decrease with birth rank, and there was no deficit of mothers of A × O matings delivered of a live child, nor of Group A children in the entire sample.

(6) No excess of heterospecific matings was found in a group of matings in which abortions had occurred.

(7) The Rh groups of 1,590 families were determined. The Rh status of the parents exerted no influence on the numbers of children of Groups O and A born of A × O and O × A matings.

(8) Apart from rare instances of maternal AB iso-immunization, it is believed that the ABO group of the parents and the maternal natural agglutinins exert little or no effect on the numbers of children of each ABO group born of the various mating types.

I am grateful to Dr. A. C. Spence for providing facilities to carry out this work, to Mr. D. M. Stern for access to the material, to his staff for their co-operation, to Dr. M. Lubran for advice on the statistical analysis of the data, and to Dr. P. L. MacKinlay for kindly reading the manuscript.

REFERENCES

Allan, T. M. (1953). *British Journal of Preventive and Social Medicine*, **7**, 220.

Boorman, K. E. (1950). *Ann. Eugen. (Camb.)*, **15**, 120.

——, Dodd, B. E., and Trinick, R. H. (1949). *Lancet*, **1**, 1088.

Bryce, L. M., Jakobowicz, R., McArthur, N., and Penrose, L. S. (1950). *Ann. Eugen. (Camb.)*, **15**, 271.

Dobson, A. M., and Ikin, E. W. (1946). *J. Path. Bact.*, **58**, 221.

Hart, E. W. (1944). *Ann. Eugen. (Camb.)*, **12**, 89.

Hirszfeld, L. (1928). "Konstitutionsserologie und Blutgruppenforschung", Springer, Berlin.

—— (1934). *Ergebn. Hyg. Bakt.*, **15**, 54.

—— (1949). *Rev. Hémat.*, **4**, 464.

Kirk, R. L., Kirk, M., and Stenhouse, N. S. (1953). *British Journal of Preventive and Social Medicine*, **7**, 1.

Levine, P. (1943). *J. Hered.*, **34**, 71.

Loghem, J. J. van, Hart, M. v.d., and Paulussen, A. M. H. (1950). *Rev. Hémat.*, **5**, 371.

Medical Research Council (1943). "The Determination of Blood Groups." War Memorandum, No. 9. H.M.S.O., London.

—— (1948). "The Rh Blood Groups." *Ibid.*, No. 19.

Mollison, P. L., and Cutbush, M. (1949). *Lancet*, **2**, 173.

—— Mourant A. E., and Race, R. R. (1948). "The Rh Blood Groups," Med. Res. Coun. Mem., No. 19. H.M.S.O., London.

Race, R. R., and Sanger, R. (1950). "Blood Groups in Man". Blackwell, Oxford.

Roberts, J. A. F. (1948). *Ann. Eugen. (Camb.)*, **14**, 109.

Sjöstedt, S., Grubb, R., and Linell, F. (1951). *Acta. path. microbiol. scand.*, **28**, 375.

Struthers, D. (1951). *British Journal of Social Medicine*, **5**, 223.

Waterhouse, J. A. H., and Hogben, L. (1947). *Ibid.*, **1**, 1.

Wiener, A. S., Wexler, I. B., and Hurst, J. G. (1949). *Blood*, **4**, 1014.

Brit. J. prev. soc. Med. (1954), **8**, 124–127

SEX RATIO AND THE ABO BLOOD GROUP SYSTEM

BY

J. M. JOHNSTONE

From the Department of Pathology, the University and Western Infirmary, Glasgow

An interesting association between the sex ratio at birth and the ABO blood group system has been demonstrated by Sanghvi (1951). He showed, in each of two population samples, one from New York and the other from Bombay, that the sex ratio (percentage of males) of Group O infants of Group O mothers was significantly higher than that of Group A infants of Group A mothers; the ratio for Group B infants of Group B mothers approximated closely with the first ratio. Allan (1952a; 1952b; 1953) further analysed Sanghvi's material and also attempted to correlate the sex ratio data with certain fertility data of various mating types compiled by Waterhouse and Hogben (1947).

This paper reports a similar analysis of an English population sample drawn from the West London and West Middlesex area.

Material

Throughout the year 1950, ABO and Rh blood group determinations were made by the tube techniques (M.R.C. Memoranda Nos. 9 and 19) on all mothers delivered in the maternity department of the West Middlesex Hospital, Isleworth, their infants, and as many of the fathers as was possible.

Analysis

The number of infants of each ABO group born to mothers of each group are detailed in Table I, the overall sex ratio is $51 \cdot 9 \pm 1 \cdot 0$.

The sex ratio, irrespective of the mother's group, for all Group B infants is $54 \cdot 4 \pm 3 \cdot 3$, for all Group O infants $52 \cdot 1 \pm 1 \cdot 5$, and for all Group A infants $51 \cdot 5 \pm 1 \cdot 6$. The sex ratio of all infants born of Group B mothers is $55 \cdot 1 \pm 3 \cdot 5$, of Group O mothers $52 \cdot 0 \pm 1 \cdot 5$, and of Group A mothers $51 \cdot 3 \pm 1 \cdot 5$. Lastly, the sex ratio of Group B infants of Group B mothers ($54 \cdot 3 \pm 5 \cdot 5$) exceeds both that of Group O infants of Group O mothers ($50 \cdot 9 \pm 1 \cdot 8$) and that of Group A infants of Group A mothers ($49 \cdot 9 \pm 1 \cdot 9$). None of the differences between the ratios in this analysis is significant, but the descending sex ratio order is B – O – A. Apart from the high sex ratio for Group B infants of Group B mothers these findings do not confirm those of Sanghvi (1951).

TABLE I

NUMBERS AND ABO BLOOD GROUPS OF INFANTS BORN TO MOTHERS OF EACH BLOOD GROUP

Infants		Mothers				Total Infants	
Group	Sex	O	A	B	AB	No.	per cent. male
O	Male	385	145	41	—	571	$52 \cdot 1 \pm 1 \cdot 0$
	Female	371	126	29	—	526	
A	Male	149	345	11	21	526	$51 \cdot 5 \pm 1 \cdot 6$
	Female	126	346	9	14	495	
B	Male	39	29	44	13	125	$54 \cdot 4 \pm 3 \cdot 3$
	Female	33	18	37	17	105	
AB	Male	—	16	18	5	39	$48 \cdot 1 \pm 5 \cdot 6$
	Female	—	18	18	6	42	
Total	Male	573	535	114	39	1,261	$51 \cdot 9 \pm 1 \cdot 0$
	Female	530	508	93	37	1,168	

The number of fathers in each group, and their children, who were available for analysis in this sample is shown in Table II (opposite).

The overall sex ratio is $51 \cdot 8 \pm 1 \cdot 0$. The sex ratio for all Group O infants, irrespective of the father's group, is $52 \cdot 5 \pm 1 \cdot 6$, for Group A infants $51 \cdot 4 \pm 1 \cdot 7$, and for Group B infants $51 \cdot 5 \pm 3 \cdot 6$; for all infants born of Group O fathers the ratio is $52 \cdot 2 \pm 1 \cdot 6$, of Group A fathers $51 \cdot 5 \pm 1 \cdot 6$, and of Group B fathers $49 \cdot 0 \pm 3 \cdot 4$. The sex ratio of Group O infants born of Group O fathers is $52 \cdot 9 \pm 1 \cdot 9$, of Group A infants of Group A fathers $51 \cdot 7 \pm 2 \cdot 0$, and of Group B infants of Group B fathers $48 \cdot 9 \pm 5 \cdot 2$. Again none of the differences between the ratios in the analysis is significant but here the descending sex ratio order is O – A – B.

TABLE II

NUMBERS AND ABO BLOOD GROUPS OF INFANTS BORN TO FATHERS OF EACH BLOOD GROUP

Infants		Fathers				Total Infants	
Group	Sex	O	A	B	AB	No.	per cent. mae
O	Male	333	140	36	—	509	52·5 ± 1·16
	Female	297	127	37	—	461	
A	Male	129	313	8	13	463	51·4 ± 1·7
	Female	121	293	9	14	437	
B	Male	24	9	45	23	101	51·5 ± 3·6
	Female	28	12	47	8	95	
AB	Male	—	17	14	6	37	49·3 ± 5·8
	Female	—	20	14	4	38	
Total	Male	486	479	103	42	1,110	51·8 ± 1·0
	Female	446	452	107	26	1,031	

In this population sample, therefore, all that may be said at this point is that children of Group B mothers tend to have a high sex ratio, while those of Group B fathers are associated with a low sex ratio. This may be further examined by the determination of the sex ratios of children born to the various ABO mating types.

Altogether the ABO groups of the mothers and fathers of 2,100 matings are available. Only one child of each mating has had a blood group determination, but the sex of 3,791 children born of these matings is known. The full details are given in Table III, the mating types having been arranged in descending order according to sex ratio. The numbers of some of the rarer mating types are too small for comparison, but are given for the sake of completeness.

Again the difference between the sex ratios of children born to Group B mothers and fathers is apparent. In the case of the children of Group B mothers, the sex ratio for each mating is well above 50 per cent., and for those with Group B fathers it is less than 50 per cent., excepting the mating B × B. Excluding this mating, the average sex ratio for each mating with a mother of Group B (O × B; A × B; AB × B) is 55·4 ± 2·9, and that for matings with Group B fathers (B × O; B × A; B × AB) is 47·5 ± 2·7. The difference between the two ratios falls only just outside the 0·05 level of probability ($\chi^2 = 3·799$).

Allan (1952b, 1953), reviewing the data of Waterhouse and Hogben (1947) and of Sanghvi (1951), noted differences in fertility associated with both sex and blood group. Disregarding matings in which both partners were of the same group, for fathers the descending order of fertility was B – AB – O – A, while the reverse (A – O – AB – B) was true for mothers, irrespective of whether the matings were homospecific or heterospecific. These differences were not observed in this sample, no definite fertility order being apparent for either mother or father (Table III, column 8).

TABLE III

FERTILITY AND SEX RATIO DATA OF VARIOUS MATING TYPES

Parents' Blood Group		Number of Matings	Number of Children	Sex of Children		Per cent. Male	Fertility
Father	Mother			Male	Female		
AB	B	8	11	8	3	72·7	1·37
AB	O	26	54	39	15	72·2	2·08
B	B	16	25	15	10	60·0	1·56
O	B	71	133	74	59	55·6	1·87
A	B	75	136	73	63	53·7	1·81
O	AB	24	52	27	25	51·9	2·17
O	O	446	799	412	387	51·6	1·79
A	O	401	693	353	340	50·9	1·73
O	A	386	701	351	350	50·1	1·82
A	A	402	741	370	371	49·9	1·84
B	O	95	167	81	86	48·5	1·76
AB	A	27	43	20	23	46·5	1·59
B	A	84	157	73	84	46·5	1·87
B	AB	8	13	6	7	46·2	1·62
A	AB	29	63	28	35	44·4	2·17
AB	AB	2	3	1	2	33·3	1·50
Total	..	2,100	3,791	1,931	1,860	50·9	1·81

DISCUSSION

The reason for the difference in the sex ratios of live births is not fully understood, and it has been explained by postulating differential conception rates. Theoretically equal numbers of *X*- and *Y*-bearing spermatozoa should be produced, but a hypothetical system whereby a certain limit of deviation might occur has been described by Novitski (1951, 1953).

More readily determined is the effect of abortions and stillbirths on the sex ratio of live births. It has been shown by Ciocco (1938a), Lowe and McKeown (1950), and McKeown and Lowe (1951), that the sex ratio of foetus lost by abortions and stillbirths varies according to the period of gestation and also depends to some extent on the various causes and conditions. This may explain some of the variations in the sex ratio of live births seen under certain conditions and avoids any need to postulate any differential conception rate.

It has been held that serological factors may influence the numbers of children of each blood

group born to various mating types, and Hirszfeld (1928) and later Waterhouse and Hogben (1947) claimed there to be a deficiency of Group A children born of the heterospecific A × O matings. This was not substantiated by Hirszfeld in a second paper (1934), nor in an analysis of the population from which this sample is taken (Johnstone, 1954). In Table III the descending order of sex ratio is seen to bear no relationship to the type of mating (*i.e.* whether homospecific or heterospecific).

An association is recognized between birth rank and sex ratio, the ratio being highest in the first rank and steadily falling thereafter to the fourth or fifth rank. Further, sex ratio is not correlated with maternal age except inasmuch as with increasing maternal age the likelihood of further pregnancies is increased; any relationship which may exist between the age of the parents and the sex ratio appears to be associated with the age of the father (Russell 1936; Ciocco 1938b; Martin 1948; Lowe and McKeown 1950; Novitski 1953; MacMahon and Pugh 1953). In Table IV the sex ratio for each birth rank is given for the matings in which either the father or mother is of Group B in the present sample. In the first rank the low ratio for children of Group B fathers and the high ratio for children of Group B mothers are obvious. The difference is highly significant ($\chi^2 = 8{\cdot}43$; $\cdot 01 > P > \cdot 001$); in the other ranks the differences are not significant, but here the numbers of children are much smaller. Occurring as it does in the first rank, this difference is most unlikely to be due to any serological cause, especially as it is not repeated in the other ranks. In this connection it is interesting that Allan (1953) has found in the family data compiled by Waterhouse and Hogben (1947) that fathers of Group B have the highest fertility while mothers of Group B have the lowest fertility.

While the sex ratios differ between children of Group B mothers and fathers, in the whole sample the differences between the reciprocal matings tend to cancel out one another, the mean percentage of males in the matings O × B and B × O (1·06) and A × B and B × A (0·99) being close to those in other matings, such as the mean of O × A and A × O (1·02), O × O (1·06), and A × A (0·99).

It is most probable therefore, that although there is a considerable difference between the sex ratios of children born to Group B mothers and fathers, particularly in the first rank, this difference is unlikely to affect to any extent the proportion of male children born to any population, or the number of Group B persons from one generation to another.

Summary

(1) A West London population has been examined for any association between the ABO blood group system and the sex ratio.

(2) In heterozygous matings more male children are born to Group B mothers than to the wives of Group B fathers. The difference is significant in the first birth rank.

(3) It is suggested that this difference will have no effect on the proportion of male children born to any given population, or on the number of persons of Group B in that population over several generations.

(4) The finding of Sanghvi (1951) that the sex ratio of Group O infants born to Group O mothers is significantly higher than that of Group A infants born to Group A mothers has not been confirmed.

I am indebted to Mr. D. M. Stern for allowing me access to the clinical material, and to the medical and nursing staff of his department for their co-operation, and also to Dr. P. L. McKinlay who kindly read the manuscript.

TABLE IV

SEX RATIOS BY BIRTH RANK FOR MATINGS IN WHICH EITHER THE FATHER OR MOTHER IS OF GROUP B, IRRESPECTIVE OF THE GROUP OF THE CHILD

Mating		Father {Sum of B × O, B × A, B × AB} Mother			Father {Sum of O × B, A × B, AB × B} Mother		
Birth Rank		1	2	3 onward	1	2	3 onward
Number of Children	Male	83	51	26	93	38	24
	Female	106	42	29	63	40	22
Per Cent. Male		43·9	54·8	47·3	59·6	48·7	52·2

REFERENCES

Allan, T. M. (1952a). *Lancet*, **1**, 102.

—— (1952b). *Ibid.*, **1**, 370.

—— (1953). *British Journal of Social Medicine*, **7**, 220.

Ciocco, A. (1938a). *Hum. Biol.*, **10**, 235.

—— (1938b). *Ibid.*, **10**, 36.

Hirszfeld, L. (1928). "Konstitutionsserologie und Blutgruppenforschung". Springer, Berlin.

—— (1934). *Ergebn. Hyg. Bakt.*, **15**, 54.

Johnstone, J. M. (1954). *British Journal of Preventive and Social Medicine*, **8**, 117.

Lowe, C. R., and McKeown, T. (1950). *British Journal of Social Medicine*, **4**, 75.

MacMahon, B., and Pugh, T. F. (1953). *Ibid.*, **7**, 83.

Martin, W. J. (1948). *Med. Offr*, **79**, 153.

McKeown, T., and Lowe, C. R. (1951). *Hum. Biol.*, **23**, 41.

Medical Research Council (1943). "The Determination of Blood Groups". War Memorandum, No. 9. H.M.S.O., London.

Mollison, P. L., Mourant, A. E., and Race, R. R. (1948). "The Rh Blood Groups". Med. Res. Coun. Mem. No. 19. H.M.S.O., London.

Novitski, E. (1951). *Genetics*, **36**, 267.

—— (1953). *Science*, **117**, 531.

Russell, W. T. (1936). *J. Hyg.* (*Lond.*), **36**, 381.

Sanghvi, L. D. (1951). *Nature* (*Lond.*), **168**, 1077.

Waterhouse, J. A. H., and Hogben, L. (1947). *British Journal of Social Medicine*, **1**, 1.

Brit. J. prev. soc. Med. (1954) **8**, 128–137

SOCIAL CLASS VARIATIONS IN MORTALITY

BY

W. P. D. LOGAN

General Register Office, London

An analysis has recently been published of mortality in England and Wales in 1950 by what are customarily called the Registrar-General's "Social Classes" (Registrar-General, 1954).

SOCIAL CLASSES.—The basic unit of the social class grouping is the occupational group. Every occupation in the country, of which there are many thousands, is assignable to one or other of 586 occupational unit groups (General Register Office, 1951). These 586 occupational groups are each assigned as a whole to one or other of five social classes (Table I), on the basis of the predominant characteristics of the majority of the persons in the unit group. The general implication is that classes so composed will reflect the differing social make-up and environment normally associated with persons within those occupational categories. The social class grouping is thus not a classification of individuals, and in assigning an individual to the appropriate social class no account is taken of personal circumstances other than occupation. Having established the occupation, the social class grading follows automatically. Moreover, as well as ignoring individual circumstances other than occupation, the social classification, in treating the occupational group as a whole, makes no special provision for particular occupational minorities within the group, that might, if considered by themselves, qualify for a different grading from that to which their occupational group as a whole has been assigned.

Accordingly, having determined an individual's occupation, the group to which that occupation belongs is immediately established, and the occupational group as a whole is assignable automatically to one or another of the five social classes. For instance, if John Jones is a plumber's mate, the classification of occupations shows that he belongs to Occupational Group No. 201 (Plumbers' Labourers), and the classification also shows that this occupational group as a whole belongs to Social Class IV (Partly Skilled Occupations). On the other hand had he been a plumber and jointer's mate he would have belonged to Occupational Group No. 940 (Labourers and other Unskilled Workers in Metal Working, Engineering, Electrical, and Allied Trades), and the whole of this very large group is assigned to Social Class V (Unskilled Occupations).

TABLE I

PERCENTAGE DISTRIBUTION OF OCCUPIED AND RETIRED MEN AGED 15 AND OVER BY FIVE SOCIAL CLASSES. (ENGLAND AND WALES 1951 CENSUS, 1 PER CENT. SAMPLE)

Social Class	Occupations	Percentage Distribution
I	Professional, etc.	3·3
II	Intermediate	15·0
III	Skilled	52·7
IV	Partly-Skilled	16·2
V	Unskilled	12·8
Total All Classes, 15,467,700		100

DEVELOPMENT OF OCCUPATIONAL AND SOCIAL CLASS MORTALITY STUDIES

As the social classes are constructed on the basis of an occupational classification, the study of social class mortality variations is a development from the study of mortality in individual occupational groups. It is just over 100 years since the first official study of occupational mortality in Great Britain was undertaken. This was an analysis (Table II) of deaths from all causes in 1851 in several hundred occupations, related to the populations of these occupations as determined by the 1851 Census (Registrar-General, 1855). Similar studies were made of deaths in 1860–61 in relation to the 1861 Census, and thereafter at 10-year intervals in or around each successive Census year, standardized death rates being introduced to allow for differences in the age structure of different occupations, and separate causes of death studied. In 1910–12 the occupational mortality analysis distinguished 132 occupational groups and 27 causes

TABLE II

MORTALITY PER 1,000 MALES AGED 45–54 IN SELECTED OCCUPATIONS (ENGLAND AND WALES, 1851)

Occupation	Death Rate
Farmer	11·99
Shoemaker	15·03
Weaver	15·37
Grocer	15·79
Blacksmith	16·51
Carpenter	16·67
Tailor	16·74
Labourer	17·30
Miner	20·15
Baker	21·21
Butcher	23·10
Inn-keeper	28·34
All Occupations	17·87

of death at ages 25–64 (Registrar-General, 1923). In this analysis, and also in a study of infant mortality in 1911 (Registrar-General, 1913), the various occupations were for the first time grouped together into *Social Classes*, of which on this occasion there were eight (Table III). The first five were graded in much the same way as in Table I, but three important occupational groups were kept apart and classed separately as Social Classes VI, VII, and VIII (Stevenson, 1923).

TABLE III

DEATH RATES OF OCCUPIED AND RETIRED MEN BY SOCIAL CLASS

Percentage of rates for all occupied and retired men, ages 25–64 (standardized)
(ENGLAND AND WALES, 1910–12)

Social Class		Mortality Ratio
I	Upper and Middle Classes ..	88
II	Intermediate	94
III	Skilled workmen	96
IV	Intermediate	93
V	Unskilled workmen	142
VI	Textile workers	101
VII	Miners	94
VIII	Agricultural labourers	59
All Classes		100

In 1921–23 (Registrar-General, 1927), deaths were tabulated for forty causes in 164 occupational groups, the occupational classification being considerably improved and made more properly *occupational* as distinct from *industrial* as it had previously tended to be. Five Social Classes only were distinguished, Classes VI to VIII of the previous classification being merged with the others (Stevenson, 1928).

We come now to the most recent occupational mortality analysis, that for the years 1930–32 (Registrar-General, 1938). For males this was on the same lines as before, but with further details of causes of death and of occupations. A new departure was the study of the mortality of single women classified by their own occupations, and of married women classified by the occupation of the husband. There are some special difficulties in studying the occupational mortality of single women. For example, many are unoccupied or are only transitorily in employment—and it was because of these difficulties that they had not previously been included; and I should not like to claim that their inclusion in 1930–32 has really got us very far.

Analysing the mortality of married women according to the husband's occupation was, however, a great step forward. It has allowed comparison between the mortality of men in particular occupations and of their wives who generally share the same socio-environmental circumstances as the husbands but are not usually exposed to their occupational hazards or disadvantages. It thus became possible in 1930–32 to begin to distinguish between mortality risks that were primarily of occupational origin (though not necessarily due to direct occupational hazards), and those arising rather from the socio-economic environments in which people in various kinds of occupations tend to live (Stocks, 1938).

LIMITATIONS OF THIS METHOD OF ENQUIRY.—There are well-recognized limitations in the study of occupational mortality, and, to a less extent in that of social class mortality, by the method traditionally employed—which depends upon relating occupational information obtained at death registration to occupational information derived from the Census. These limitations have been discussed in great detail in the various official reports and only two will be mentioned here.

One type of error can arise from differences between the occupational description given by an individual himself on the Census schedule and that given by a relative when registering his death. The individual probably knows best what his occupation really is, but may not describe it properly or in sufficient detail on the Census schedule; whereas when a death is registered the Registrar is in a position to elicit details, including information about the previous occupation of a retired person, though occasionally the informant may not have sufficient knowledge to provide the information accurately.

Another type of difficulty arises in attempting to interpret the recorded mortality rates; it then becomes necessary to consider the extent to which an apparently high or low mortality rate recorded for an occupation may be due to physically or medically selective recruitment or discharge. For example the police force may recruit only the physically fit, whereas other types of occupation may attract or become the refuge of invalids or persons of poor physique. The recorded mortality rates for such occupations might reflect the type of people engaged therein more than the risks of the occupation itself. Furthermore, the recorded mortality rate of a dangerous or physically onerous occupation may be understated, owing to persons in failing health transferring themselves to a less exacting job some time before death.

STUDIES IN OTHER COUNTRIES.—In this field of occupational and social class mortality studies work has been done in England and Wales on a much larger scale than elsewhere. A valuable survey of

what has been done in various countries has been given by Daric (1949), from whom some of the following information has been taken.

Scotland.—Occupational variations in mortality were studied in relation to the Census of 1891 and 1901, and infant mortality and stillbirth statistics by social class have been published for 1939 and annually since 1944.

France.—Villermé (1840) made a small study of mortality in relation to occupation and social class in Mulhouse during 1823–34; Bertillon (1889) gave some data for Paris in 1885–89; and Huber (1912), in a much more comprehensive study, examined occupational mortality in the whole country for 1907–8 in relation to the 1906 Census. Table IV is an extract from his findings.

TABLE IV

AVERAGE ANNUAL DEATH RATES PER 10,000 MEN AGED 45–54 IN CERTAIN OCCUPATIONS (FRANCE, 1907–08 [HUBER, 1912])

Occupation	Rate per 10,000
Managers and officials	127
Clerks	203
Craftsmen and kindred workers	232
Farmers	104
Miners	204
Bakers	306
Textile workers	194
Tailors	335
Plumbers	493
Physicians and pharmacists	194
Teachers	140
Waiters	343
Total gainfully occupied	171

United States of America.—Dublin and Vane (1917, 1930, 1947) have published studies of the mortality experience of wage-earners insured with the Metropolitan Life Insurance Company. A less restricted study was that of Whitney (1934), in which he related the death registration occupational data from ten States to the 1930 Census enumeration. He grouped the occupations into seven socio-economic classes not dissimilar to those used in England and Wales (Table V).

Switzerland.—Occupational mortality studies were made for the periods 1879–82 and 1891–1900.

Netherlands.—Studies were made for the three periods 1891–95, 1896–1900, and 1908–11.

ALTERNATIVE METHODS OF SOCIAL CLASSIFICATION.—The Registrar-General's Social Classification is an arrangement of occupations into five groups graded not by some precisely measurable attribute but by the less specific but by no means imponderable characteristic of "standing in the community". It would be possible, still retaining occupation as the distinguishing unit, to devise alternative classification by grouping the occupations in other ways. One way could be to grade and group according to their recorded mortality rates. In one sense such a procedure would be absurd, since it would yield not a gradient of *social* classes but of *mortality* classes, and could not be used legitimately to demonstrate correlation between mortality and social class defined independently of mortality; but for certain purposes, as for instance occupational standardization of local rates, such a classification might be better than any other.

TABLE V

STANDARDIZED DEATH RATES PER 1,000 OCCUPIED MALES AGED 15–64 IN SELECTED OCCUPATIONS ACCORDING TO SOCIO-ECONOMIC CLASS, AND PER CENT. OF RATE FOR ALL OCCUPIED MALES (UNITED STATES OF AMERICA, 1930 [WHITNEY, 1934])

	Socio-economic Class	Standardized death rate	Mortality Ratio
I	Professional men	6·7	74
II	Proprietors, managers, and officials	7·9	87
III	Clerks and kindred workers	7·8	87
IV	Agricultural workers	6·2	68
V	Skilled workers and foremen	8·3	91
VI	Semi-skilled workers	10·1	111
VII	Unskilled workers	14·5	159
	All gainfully occupied males in selected occupations	9·1	100

A new grouping of occupations that has been included in the 1951 Census One per cent. Sample Tables (Registrar-General, 1952) comprises thirteen socio-economic groups. This classification has been used for the tabulation of fertility and of households (Table VI, opposite), but not yet in connexion with mortality.

A quite different type of occupational reclassification, unrelated to *social* criteria, was used recently by Morris and Heady (1953), who compared the mortality in 1930–32 from certain causes amongst men, classifying their occupations by the amount of physical activity involved, *viz.* heavy workers, intermediate and doubtful, and light workers. A further classification, introduced only for research into cancer of the lung, was "smoking possible" and "smoking prohibited".

Various other groupings of occupation could be devised on the basis of other criteria deemed likely to yield a social differentiation, as for instance, the attachment to each occupation of some estimate of its average level of education, income, housing standards, and the like.

Putting occupation aside, the criteria just instanced could themselves be used as the units of classification; that is to say, individuals might be classified not by occupation but directly by their individual level of education, income, housing, etc. Unfortunately the practical difficulties are great: dependable information would not be forthcoming from the Census and would have to be obtained otherwise, while questions

TABLE VI

PERCENTAGE DISTRIBUTION OF HOUSEHOLDS CLASSIFIED BY SOCIO-ECONOMIC GROUP OF HEAD OF HOUSEHOLD. (ENGLAND AND WALES, 1951 CENSUS 1 PER CENT. SAMPLE)

Socio-Economic Group		Per cent. Distribution
(A) Agricultural	1. Farmers	2·1
	2. Agricultural workers	3·5
(B) Non-Agricultural		
I Non-Manual	3. Higher administrative, professional, and managerial (including large employers)	2·9
	4. Intermediate do. (including teachers and salaried staff)	9·7
	5. Shopkeepers and small employers	4·3
	6. Clerical workers	4·4
	7. Shop assistants	2·6
	8. Personal Service	3·5
II Manual	9. Foremen	3·4
	10. Skilled workers	29·7
	11. Semi-skilled workers	9·5
	12. Unskilled workers	9·5
(C) Special group not included elsewhere	13. Armed forces (other ranks)	0·3
	Not Classified	14·7
	Total	100
	Total number	13,043,500

about education and housing, and still less about income, would not be answered accurately and would be inappropriate at death registration.

Though it is admittedly imperfect, it will not be easy to find a more practically convenient criterion than that of occupation.

There is, however, another widely-used though rather crude unit of classification, namely area of residence. This has the advantage, like occupation, of being an item of information about the individual that is entered both on registration and census records. Using this criterion, all the individuals living in one area, in a town or part of a town, are classified together as belonging to one particular "social" group, no regard being paid to other circumstances of the individual that might suggest that he did not in fact belong to that group. There is thus a clear resemblance to using whole occupational groups as the unit, regardless of individual discrepancies, but in the case of *area* the individual discrepancies are likely to be wider and the resulting social classification less sensitive. Having decided upon the use of area as the unit, their allocation to various social groups can be made on the basis of a rough and ready non-specific kind of grading in which, for instance, one might, from general experience, decide to grade Belgravia higher than Pimlico, or Hampstead higher than Kentish Town; or alternatively the grading and grouping of the areas might be made in accordance with some definite and measurable characteristic, such as standard of housing, overcrowding, number of public houses, proportion of the population in certain types of occupation, or even the local mortality rate itself, as was done in some of the early reports of the General Register Office.

Lastly, one further type of classification should be mentioned, which has not yet been used for mortality comparisons, namely classification by industrial status. Here individuals are classified not by occupational group or locality of residence but by their relationship to their trade or employment. Table VII shows the industrial status groupings adopted in the 1951 Census.

TABLE VII

PERCENTAGE DISTRIBUTION OF MEN AGED 15 AND OVER BY INDUSTRIAL STATUS. (ENGLAND AND WALES, 1951 CENSUS, 1 PER CENT. SAMPLE)

Status Aggregates		Per Cent. Distribution
Employers		2·1
Managers	General managers, Directors, etc.	1·0
	of branch or primary Departments	2·1
	of office or subsidiary departments	0·6
Operatives	Social Classes I and II	7·4
	Others	67·9
Working on own account		5·1
Out of work		1·7
Unoccupied	Retired	8·7
	Others	3·4
Included in Operatives	Apprentices and articled employees	2·2
	Part-time workers	0·3
	Unpaid assistants	0·1
Total		100
Total number		16,018,700

THE 1950 ANALYSIS

This deals with deaths in 1950 related to the results of the 1951 Census One per cent. Sample, and constitutes a preliminary, and much restricted survey of what we may expect to find in the full analysis which will cover deaths in the 5 years 1949–53, and give greater detail than ever of occupations and of causes of death. Since this full analysis will not be completed for several years, and it is now over 20 years since the last one was made, it seemed desirable to take advantage of the opportunity offered by the One per cent. Sample population data to prepare some advance tables, deliberately limited to the main social classes and some major divisions of these, and to a few of the most important causes of death.

For full details readers should refer to the official report (Registrar-General, 1954).

Table VIII and Fig. 1 compare the standardized mortality ratios (S.M.Rs) of men aged 20–64 in the five social classes in 1950 with those recorded in 1921–23 and 1930–32.

In 1921–23 and 1930–32 there was an uninterrupted upward gradient of mortality from Social Class I (professional) to Social Class V (unskilled). In 1950 the gradient was much less regular, the lowest ratios being given by Social Classes II and IV. All kinds of suggestions might be made to explain this departure in 1950 from the former regular gradient. But, remembering that the ratios have been calculated with only one year's deaths as numerator and a One per cent. Census Sample as denominator, it would be advisable to await more comprehensive figures before exploring the various possibilities in detail. It is difficult to believe that the irregular trend can have arisen only as a result of random fluctuation in the figures.

The social class mortality gradient for married women (Table VIII and Fig. 2) has also become less regular in 1950 than it was in 1930–32, the only

TABLE VIII

STANDARDIZED MORTALITY RATIOS OF MEN AND MARRIED WOMEN AGED 20–64 BY SOCIAL CLASS. (ALL CAUSES 1921-23, 1930–32, AND 1950)

Category	Date	Social Class				
		I	II	III	IV	V
Men aged 20–64	1921–23	82	94	95	101	125
	1930–32	90	94	97	102	111
	1950	97	86	102	94	118
Married women aged 20–64	1930–32	81	89	99	103	113
	1950	96	84	101	104	117

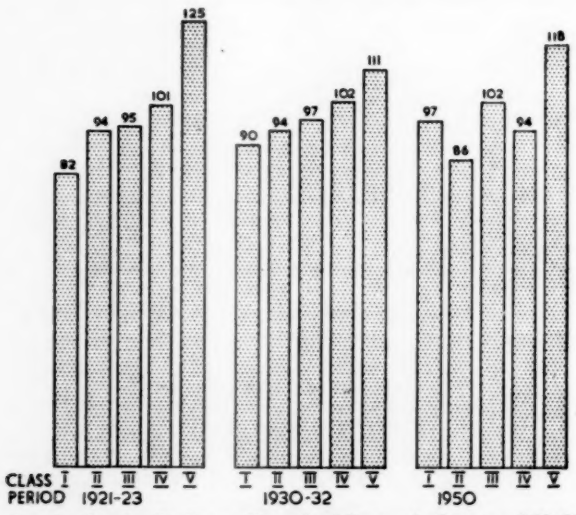

FIG. 1.—Standardized mortality ratios (all causes) of men aged 20–64, by social class.

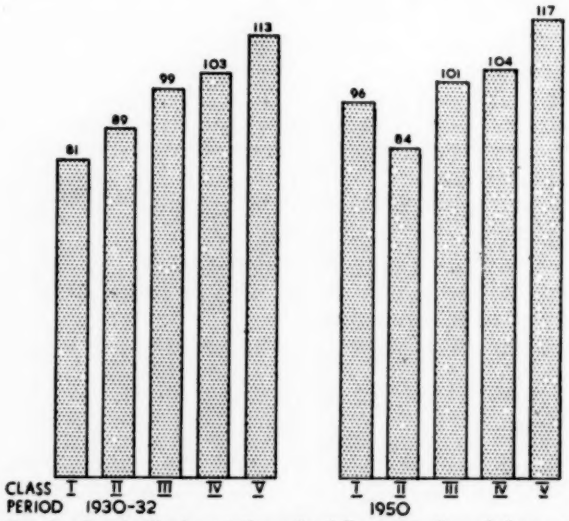

FIG. 2.—Standardized mortality ratios (all causes) of married women aged 20–64, by social class of husband.

SELECTED DISEASES. STANDARD MORTALITY RATIOS AT AGE 20–64 AND PROPORTIO

Disease			Respiratory Tuberculosis					Cancer										
								Stomach†					Lung					
Social Class			I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V	
Age 20–64	Men	1921–23	49	81	95	97	137	60	82	100	106	130	100	109	97	79	124	
		1930–32	61	70	100	104	125	*59	*84	*98	*108	*124	107	95	100	92	114	
		1950	64	62	103	95	149	57	67	100	114	132	80	79	108	89	116	
	Married Women	1930–32	52	67	99	106	132	*54	*78	*104	*104	*121	*95*	100	108	81	94	(Br
		1950	*43*	52	104	107	166	*57*	72	101	106	138	*120*	94	104	96	91	(Br (Ce
Age 65+	Men	1950	*77*	62	106	92	143	70	86	101	110	113	108	89	105	79	118	
	Married women	1950	*107*	*107*	91	*88*	*126*	*81*	88	103	105	107	*176*	99	97	*92*	*103*	(Br (Ce

* Including oesophagus.

† Men aged 35–64, instead of 20–64, in 1930–32.

TABLE IXA

STANDARDIZED MORTALITY RATIOS OF MEN AND OF MARRIED WOMEN AGED 20–64 IN SOCIAL SUB-CLASSES (ALL CAUSES, 1950)

Social Class	Sub-Class		Standardized Mortality Ratios 20–64	
			Men	Married Women
III	*a*	Mineworkers	138	142
	b	Transport workers.. ..	104	102
	c	Clerical workers	114	92
	d	Armed forces	133	336
	e	Others	98	98
IV	*a*	Agricultural workers ..	80	102
	b	Others	97	105
V	*a*	Building and dock labourers	83	97
	b	Others	130	124

TABLE IXB

STANDARDIZED MORTALITY RATIOS OF MEN AND OF MARRIED WOMEN AGED 20–64 IN SELECTED OCCUPATIONAL GROUPS (ALL CAUSES, 1950)

Social Class	Sub-Class	Occupation	Standardized Mortality Ratios 20–64	
			Men	Married Women
II	–	Farmers	73	91
III	*a*	Hewers and getters ..	154	148
III	*e*	Foremen in engineering, etc.	67	64
IV	*b*	Mineworkers	96	120
V	*a*	Building labourers ..	79	95
V	*a*	Dock labourers	102	106

previous occasion on which this group was studied. However, only Social Class II was out of step; the others increased from Social Classes I to V.

The 1950 Classification of Occupations has introduced a number of major sub-divisions of Social Classes III, IV, and V. These "sub-classes" are purely occupational groupings within their respective social classes, and have no implied social grading such as that between the main classes. Table IXA shows the S.M.Rs of men and married women in nine sub-classes, and Table IXB shows in addition those for six large occupational groups for which population estimates happen to have been obtained from the One per cent. Sample Census tabulations. For men high S.M.Rs have been given by skilled mine workers, particularly hewers and getters (S.M.R. 154), members of the Armed Forces (133), and the unskilled workers in Social Sub-class Vb (130). In contrast are the low indices for engineering foremen (67), farmers (73), and builders' labourers (79).

Among married women, high ratios are shown for the wives of mine workers and unskilled workers, suggesting that the high mortality risks of their husbands may be of social rather than of purely occupational origin. The S.M.R. of 336 for wives of members of the Armed Forces is artificially inflated and should be disregarded.

INDIVIDUAL CAUSES OF DEATH (Table X).—Mortality from over thirty causes of death has been tabulated for 1950; Table X shows how the results for a few of these causes compare with earlier findings. The P.M.Rs at age 65 and over included in this Table are "Proportionate Mortality Ratios", *viz.* the proportion of deaths at age 65 and over attributed to the cause in question in a given social class expressed as a percentage of the corresponding proportion in all classes. Proportionate ratios have been used because ratios calculated upon the enumerated populations in the various occupational groups tend to be unreliable at advanced ages, chiefly owing to confusion between "unoccupied" and "retired".

TALITY RATIOS AT AGE 65+, OF MEN AND MARRIED WOMEN BY SOCIAL CLASS

Cervix Uteri			Leukaemia					Coronary Heart Disease†					Myocardial Degeneration†					Bronchitis					Diabetes Mellitus				
III	IV	V	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V
			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	26	55	94	121	177	125	145	92	75	66
			153	125	96	94	85	237	148	95	66	67	77	92	94	105	122	31	57	91	124	156	122	155	95	82	69
			153	101	107	81	88	150	110	104	79	89	67	82	97	98	137	33	53	97	103	172	*167*	97	97	91	*108*
103	84	82	*167*	118	107	76	76	157	126	93	85	88	54	75	99	110	129	*27*	56	99	119	155	56	89	104	108	106
106 98	76 109	97 150	*145*	*73*	110	*91*	*95*	92	93	101	100	108	*66*	67	98	120	134	*33*	48	100	130	152	*86*	88	98	109	117
			235	118	94	*94*	*65*	150	116	101	85	81	87	99	98	111	99	50	72	103	107	130	*130*	139	100	78	72
105 105	77 89	83 113	*118*	*59*	*109*	*91*	*145*	128	108	100	91	91	72	96	99	110	104	*45*	78	98	117	129	*65*	96	96	106	126

† Men aged 35–64, instead of 20–64, in 1930–32.

Table VIII and Fig. 1 compare the standardized mortality ratios (S.M.Rs) of men aged 20–64 in the five social classes in 1950 with those recorded in 1921–23 and 1930–32.

In 1921–23 and 1930–32 there was an uninterrupted upward gradient of mortality from Social Class I (professional) to Social Class V (unskilled). In 1950 the gradient was much less regular, the lowest ratios being given by Social Classes II and IV. All kinds of suggestions might be made to explain this departure in 1950 from the former regular gradient. But, remembering that the ratios have been calculated with only one year's deaths as numerator and a One per cent. Census Sample as denominator, it would be advisable to await more comprehensive figures before exploring the various possibilities in detail. It is difficult to believe that the irregular trend can have arisen only as a result of random fluctuation in the figures.

The social class mortality gradient for married women (Table VIII and Fig. 2) has also become less regular in 1950 than it was in 1930–32, the only

TABLE VIII

STANDARDIZED MORTALITY RATIOS OF MEN AND MARRIED WOMEN AGED 20–64 BY SOCIAL CLASS. (ALL CAUSES 1921–23, 1930–32, AND 1950)

Category	Date	Social Class				
		I	II	III	IV	V
Men aged 20–64	1921–23	82	94	95	101	125
	1930–32	90	94	97	102	111
	1950	97	86	102	94	118
Married women aged 20–64	1930–32	81	89	99	103	113
	1950	96	84	101	104	117

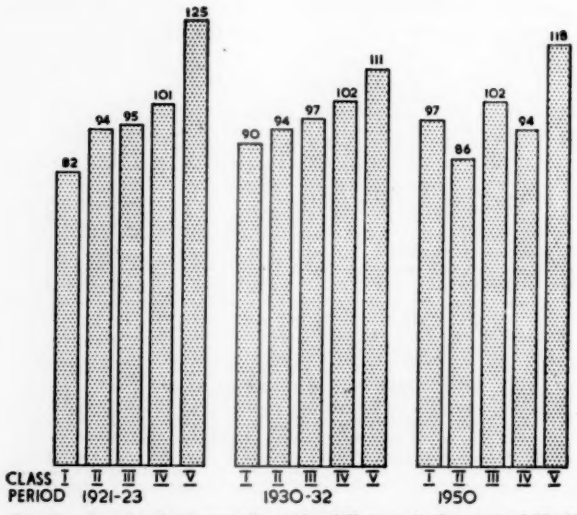

FIG. 1.—Standardized mortality ratios (all causes) of men aged 20–64, by social class.

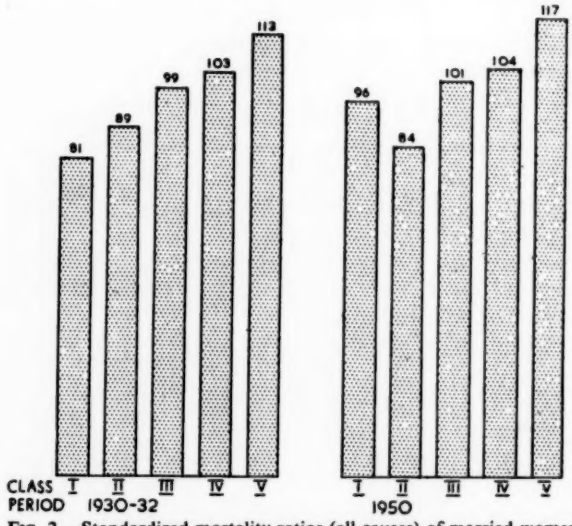

FIG. 2.—Standardized mortality ratios (all causes) of married women aged 20–64, by social class of husband.

SELECTED DISEASES. STANDARD MORTALITY RATIOS AT AGE 20–64 AND PROPORTIONA

Disease			Respiratory Tuberculosis					Cancer										
								Stomach†					Lung					Br
Social Class			I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V	I
Age 20–64	Men	1921–23	49	81	95	97	137	60	82	100	106	130	100	109	97	79	124	
		1930–32	61	70	100	104	125	*59	*84	*98	*108	*124	107	95	100	92	114	
		1950	64	62	103	95	149	57	67	100	114	132	80	79	108	89	116	
	Married Women	1930–32	52	67	99	106	132	*54	*78	*104	*104	*121	*95*	100	108	81	94	(*Breast*)
		1950	*43*	52	104	107	166	*57*	72	101	106	138	*120*	94	104	96	91	(*Breast*) (*Cervix*)
Age 65+	Men	1950	*77*	62	106	92	143	70	86	101	110	113	108	89	105	79	118	
	Married women	1950	*107*	*107*	91	*88*	*126*	*81*	88	103	105	107	*176*	99	97	*92*	*103*	(*Breast*) (*Cervix*)

Cervix		
II	III	
116	10	
100	10	
69	9	
113	10	
93	10	

* Including oesophagus.

† Men aged 35–64, instead of 20–64, in 1930–32.

TABLE IXA

STANDARDIZED MORTALITY RATIOS OF MEN AND OF MARRIED WOMEN AGED 20–64 IN SOCIAL SUB-CLASSES (ALL CAUSES, 1950)

Social Class	Sub-Class		Standardized Mortality Ratios 20–64	
			Men	Married Women
III	*a*	Mineworkers	138	142
	b	Transport workers	104	102
	c	Clerical workers	114	92
	d	Armed forces	133	336
	e	Others	98	98
IV	*a*	Agricultural workers ..	80	102
	b	Others	97	105
V	*a*	Building and dock labourers	83	97
	b	Others	130	124

TABLE IXB

STANDARDIZED MORTALITY RATIOS OF MEN AND OF MARRIED WOMEN AGED 20–64 IN SELECTED OCCUPATIONAL GROUPS (ALL CAUSES, 1950)

Social Class	Sub-Class	Occupation	Standardized Mortality Ratios 20–64	
			Men	Married Women
II	–	Farmers	73	91
III	*a*	Hewers and getters ..	154	148
III	*e*	Foremen in engineering, etc.	67	64
IV	*b*	Mineworkers	96	120
V	*a*	Building labourers ..	79	95
V	*a*	Dock labourers	102	106

previous occasion on which this group was studied. However, only Social Class II was out of step; the others increased from Social Classes I to V.

The 1950 Classification of Occupations has introduced a number of major sub-divisions of Social Classes III, IV, and V. These "sub-classes" are purely occupational groupings within their respective social classes, and have no implied social grading such as that between the main classes. Table IXA shows the S.M.Rs of men and married women in nine sub-classes, and Table IXB shows in addition those for six large occupational groups for which population estimates happen to have been obtained from the One per cent. Sample Census tabulations. For men high S.M.Rs have been given by skilled mine workers, particularly hewers and getters (S.M.R. 154), members of the Armed Forces (133), and the unskilled workers in Social Sub-class Vb (130). In contrast are the low indices for engineering foremen (67), farmers (73), and builders' labourers (79).

Among married women, high ratios are shown for the wives of mine workers and unskilled workers, suggesting that the high mortality risks of their husbands may be of social rather than of purely occupational origin. The S.M.R. of 336 for wives of members of the Armed Forces is artificially inflated and should be disregarded.

INDIVIDUAL CAUSES OF DEATH (Table X).—Mortality from over thirty causes of death has been tabulated for 1950; Table X shows how the results for a few of these causes compare with earlier findings. The P.M.Rs at age 65 and over included in this Table are "Proportionate Mortality Ratios", *viz.* the proportion of deaths at age 65 and over attributed to the cause in question in a given social class expressed as a percentage of the corresponding proportion in all classes. Proportionate ratios have been used because ratios calculated upon the enumerated populations in the various occupational groups tend to be unreliable at advanced ages, chiefly owing to confusion between "unoccupied" and "retired".

ORTALITY RATIOS AT AGE 65+, OF MEN AND MARRIED WOMEN BY SOCIAL CLASS

d Cervix Uteri				Leukaemia					Coronary Heart Disease†					Myocardial Degeneration†					Bronchitis					Diabetes Mellitus				
II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V
				—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	26	55	94	121	177	125	145	92	75	66
				153	125	96	94	85	237	148	95	66	67	77	92	94	105	122	31	57	91	124	156	122	155	95	82	69
				153	101	107	81	88	150	110	104	79	89	67	82	97	98	137	33	53	97	103	172	*167*	97	97	91	*108*
116	103	84	82	*167*	118	107	76	76	157	126	93	85	88	54	75	99	110	129	*27*	56	99	119	155	56	89	104	108	106
100	106	76	97	*145*	*73*	110	*91*	*95*	92	93	101	100	108	*66*	67	98	120	134	*33*	48	100	130	152	*86*	88	98	109	117
69	98	109	150																									
				235	118	94	*94*	*65*	150	116	101	85	81	87	99	98	111	99	50	72	103	107	130	*130*	139	100	78	72
113	105	77	83	*118*	*59*	*109*	*91*	*145*	128	108	100	91	91	72	96	99	110	104	*45*	78	98	117	129	*65*	96	96	106	126
93	105	89	113																									

† Men aged 35–64, instead of 20–64, in 1930–32.

Ratios calculated upon less than fifty actual deaths are italicized to indicate that their significance is uncertain.

Respiratory Tuberculosis.—For men aged 20–64 the steeply rising gradient from Social Class I to V seen in 1921–23 and 1930–32 has been repeated in 1950, but with the ratios for Social Classes II and IV rather lower than those for Social Classes I and III respectively. The P.M.Rs for elderly men show the same pattern. The gradient for married women aged 20–64 has remained steep and regular. At age 65 and over the deaths of married women from tuberculosis are few and the ratios are erratic.

Cancer of the Stomach.—Each of the series of ratios indicates a regular gradient of increasing mortality from Social Class I to V. The steepness of the gradient has remained unchanged since 1921–23.

Cancer of the Lung.—In the two previous analyses the evidence for an association between cancer of lung and social class was somewhat equivocal, but the 1950 figures for men aged 20–64 seem to suggest a rising gradient from Social Class I to V. There are no signs, however, of a similar gradient amongst married women nor amongst men aged 65 and over.

Cancer of the Breast and Cervix Uteri.—The first of these two conditions displays a definite downward gradient from Social Class I to V for married women in both of the age groups shown. The second condition displays an opposite tendency, with the lowest mortality in the married women of Social Class I and the highest mortality in Social Class V. Cancer of these two sites is known to be correlated with child bearing; mortality from cancer of the breast is lower and from cancer of the cervix higher in women who have borne children than in those who have not, the number of children borne being also important. It is likely therefore that the much higher fertility of Social Classes IV and V helps to explain the mortality pattern of these two diseases. Whether it is the only reason cannot at present be said.

Leukaemia.—This is one of the diseases that shows a downward gradient from Social Class I to Social Class V, in both sexes, though many of the ratios shown in the Table are based on inadequate numbers. Better diagnosis in Social Class I than in Social Class V *may* be the reason; this *may* also explain the steady increase year by year in the numbers of deaths that are being recorded, but this is uncertain.

Coronary Heart Disease (Fig. 3).—In 1930–32 mortality from this cause in both sexes was higher in Social Classes I and II than in Social Classes IV and V. In 1950 this gradient is still quite evident for men and for elderly married women, but for some unexplained reason the ratios for women aged 20–64 are graduated in the opposite direction, *i.e.* they rise upwards from Social Class I to V instead of declining. Possible reasons to account for the male gradient pattern include social class and occupational differences in death certificate terminology, in mental stress, in dietary habits, and in physical activity. Probably the last two factors are most important.

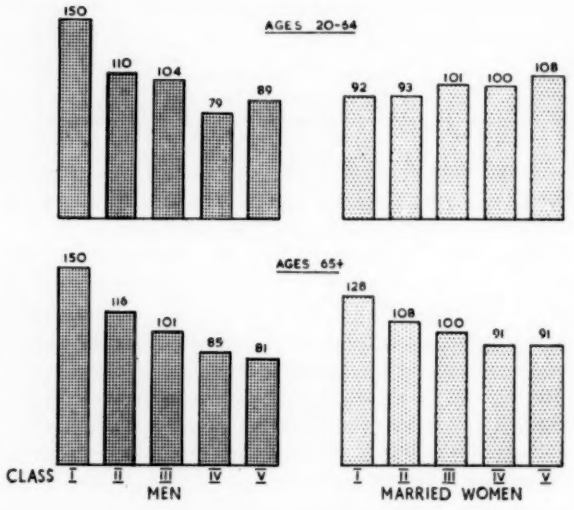

FIG. 3.—Coronary heart disease. Standardized mortality ratios of men and married women at ages 20–64, and proportionate mortality ratios at ages 65 and over, by social class (1950).

Myocardial Degeneration.—The mortality ratios for this condition amongst men aged 20–64 run in the opposite direction to those for coronary disease, being lowest in Social Class I increasing to Social Class V; the gradient for women is the same as that for men. At age 65 and over the same tendency persists, but the ratios are not quite as high in Social Class V as might be expected.

Bronchitis.—This disease gives the steepest and most uniform social class mortality gradient of all, with mortality at ages 20–64 roughly five times higher in Social Class V than Social Class I. Clearly this is something that has to be taken into account in any studies of geographical variations in the incidence of bronchitis in relation to other factors such as climate or atmospheric pollution.

Diabetes Mellitus.—This condition has been included in order to show that the sex difference in the social class mortality gradient observed in 1930–32 has persisted in 1950. For men mortality is

highest in Social Class I and declines towards Social Class V. In women the gradient runs in the opposite direction.

Pneumonia, Suicide, Ulcer of Stomach, Ulcer of Duodenum (Fig. 4).—The pattern of mortality from pneumonia in 1950 was very similar to that from bronchitis, whereas the suicide ratios gave a U-shaped distribution. Mortality from gastric ulcer and duodenal ulcer contrasted strangely, the former showing a uniform social class gradient while the latter had its lowest death rates in Social Classes II and IV.

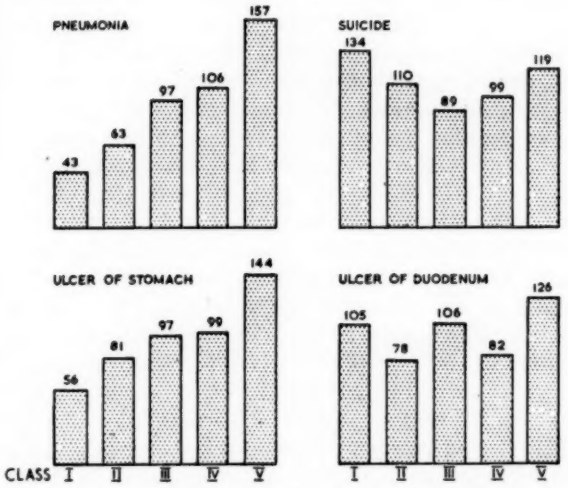

FIG. 4.—Standardized mortality ratios of men aged 20–64, by social class (1950).

STILLBIRTHS AND INFANT MORTALITY

The infant mortality rate, as has often been pointed out, is a sensitive index of social conditions, particularly as regards the post-neonatal period, *i.e.* from 4 weeks of age up to 1 year, where, as Table XI shows, the death rate is persistently four times higher in Social Class V than in Social Class I. It is worth noting that, in spite of the tremendous reduction in infant mortality rates during the past 30 years, there has been no narrowing of the difference between the various social classes, *i.e.* no tendency for the gradient to become less steep.

There has likewise been no tendency for the social class differences in stillbirth and neonatal mortality rates (deaths under 4 weeks) to become less in recent years. As Fig. 5 illustrates, however, the gradient is much less steep for stillbirths and neonatal deaths than for deaths occurring later in the first year.

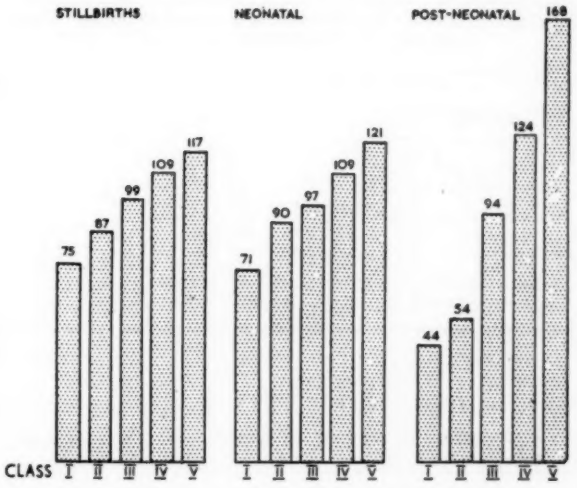

FIG. 5.—Comparative ratios of stillbirths, neonatal (under 4 weeks), and post-neonatal (4 weeks to 1 year) infant mortality by social class (1950).

Table XII indicates that a similar social class differentiation of post-neonatal mortality occurred in various parts of the country, but suggests that the comparative ratio for Social Class I was a little higher in the South of England and in the rural areas throughout the country than it was elsewhere.

TABLE XI

COMPARATIVE RATIOS OF STILLBIRTHS, NEONATAL (UNDER 4 WEEKS) AND POST-NEONATAL (4 WEEKS TO 1 YEAR) INFANT MORTALITY, BY SOCIAL CLASS OF FATHER. (LEGITIMATE ONLY)

Mortality	Year	Social Class (All Classes = 100)				
		I	II	III	IV	V
Stillbirths	1939	67	92	98	104	110
	1950	75	87	99	109	117
Neonatal	1921	69	83	99	108	109
	1930–32	72	90	97	106	108
	1950	71	90	97	109	121
Post-neonatal	1921	33	60	95	117	133
	1930–32	35	57	90	111	142
	1950	44	54	94	124	168

TABLE XII

COMPARATIVE RATIOS OF POST-NEONATAL (4 WEEKS TO 1 YEAR) INFANT MORTALITY, BY SOCIAL CLASS IN REGIONAL AND DENSITY AGGREGATES, 1950

Aggregates	Social Class (All Classes = 100)				
	I	II	III	IV	V
North	*33*	51	90	122	157
Midland and East	*48*	60	95	119	168
South	63	58	98	116	165
Wales	*30*	*52*	95	120	157
Conurbations	44	47	95	121	172
Other urban areas	*36*	53	90	128	165
Rural areas	*62*	66	95	122	149

Some of the most frequently certified causes of infant mortality are listed in Table XIII, more or less in order of steepness of social class gradient. The infections come first, *viz.* whooping cough, gastro-enteritis, and pneumonia, with rates more than five times higher in Social Class V than in Social Class I. In contrast, at the foot of the list come congenital malformations and haemolytic disease, which show only relatively small differences between the mortality rates in one social class and another.

TABLE XIII

COMPARATIVE RATIOS OF INFANT MORTALITY (DEATHS UNDER 1 YEAR) FROM EIGHT SELECTED CAUSES, BY SOCIAL CLASS, 1950

Cause of Death	Social Class				
	I	II	III	IV	V
Whooping cough ..	*20*	*33*	100	120	173
Gastro-enteritis	*28*	41	92	127	183
Pneumonia	*36*	53	89	127	176
Accidental mechanical suffocation	*59*	*46*	87	118	182
Prematurity	59	81	97	112	129
Birth injury	*68*	97	100	114	98
Congenital malformation	80	83	102	110	109
Haemolytic disease ..	*90*	110	99	96	108

CONCLUSION

As a post-script to this abridged review of occupational and social class mortality variations in England and Wales, a word may be added about the value of this kind of analysis. To tabulate one or several years' deaths by sex, age, occupation, and cause, and to calculate corresponding mortality rates is a big undertaking which could only be justified if the results were really worth having and served a useful purpose for administration or for research. On what grounds, then, are these large occupational mortality analyses justifiable?

Greenwood (1948) certainly thought them worth while when he described them as "the most valuable single instrument of socio-medical research our national armoury contains".

It cannot be claimed that our occupational mortality studies have revealed many specific industrial hazards that were not already known. The sand-blasting risk, for instance, was not discovered by a revelation in the official mortality tables that those who followed this occupation were subject to an exceptionally high mortality. In respect of occupations such as this which have a well-known special hazard the tabulations have confirmed rather than discovered the danger. In addition, however, they have allowed comparisons to be made from time to time and from one occupation to another. Sand-blasting, we know, is or was dangerous: but is it, or was it, more dangerous than hotel-keeping? In 1930–32 it was very much more dangerous, the respective standardized mortality ratios being 304 and 155. Coal gas workers and medical practitioners, who also suffer certain occupational risks, had S.M.Rs of 115 and 106, but the Anglican clergy, who apparently follow a less dangerous occupation, had a S.M.R. of only 69. We are thus given the opportunity of seeing different occupations in perspective so that the relative risk can be appraised.

By grouping together occupations that seem to enjoy much the same living standards, we are able to show, as Stevenson has already pointed out (Registrar-General, 1927), that "mortality is influenced more by the conditions of life implied by various occupations than by the direct occupational risks entailed"; and this approach to the study of mortality variations has been greatly advanced by the decision in 1930–32 to take account also of the mortality of married women. The cynic may ask what, having shown that a disease is closely correlated with adverse living conditions, we propose to do about it, for it is admittedly beyond the ordinary powers of doctors to transfer their patients from Social Class V to Social Class I and so to relieve them of some of their bronchitis, tuberculosis, and myocardial degeneration (though increasing thereby their risk of coronary thrombosis). But this is the wrong approach. Having discovered that mortality from a disease is influenced to a significant degree by so-called social conditions, the next step is to study these conditions in detail to determine precisely by what mechanism the behaviour of a disease differs in different groups of people, or in what the advantages of one group consist. It may even be practicable, having recognized that the risk from a disease is greater in one group than another, to reduce the risk by taking special precautions with the vulnerable group.

These occupational and social class mortality studies also provide additional information about epidemiology and the natural history of disease. The observation that coronary disease kills men in professional and managerial occupations much more than those doing unskilled work, does not reveal the cause or causes of the disease, but has at least provided some useful leads.

There is little doubt that these extensive occupational mortality studies have a fundamental value as instruments of medical research, and, despite their various special limitations, it is probable that such studies will be needed periodically for a long time to come.

SUMMARY

(1) An analysis is described of social class mortality in England and Wales in 1950, based upon the 1951 Census One per cent. Sample Tables.

(2) Compared with previous studies, mortality rates in Social Class II (men and married women) and Social Class IV (men only) are unexpectedly low.

(3) Social class gradients for certain individual causes of death are described.

(4) The social class gradient of infant mortality is found to be as steep in 1950 as it was 30 years earlier.

REFERENCES

Bertillon, J. (1889). "Annuaire statistique de la ville de Paris", p.186.

Daric, J. (1949). "Mortalité, profession, et situation sociale", *Population, Paris*, **4**, 671. *Republished in English in* U.S. Public Health Service (1951) "Vital Statistics—Special Reports", vol. 33, No. 10.

Dublin, L. I. (1917). Bulletin of U.S. Bureau of Labor Statistics, No. 207, "Causes of Death by Occupation".

Dublin, L.I., and Vane, R. J. (1930). *Ibid.*, No. 507.

—— —— (1947). *Monthly Labor Review*, **64**, 1003.

General Register Office (1951). "Classification of Occupations, 1950".

—— —— —— (1952). "Census 1951 Great Britain. One per cent. Sample Tables".

Greenwood, M. (1948). "Some British Pioneers of Social Medicine", p. 79. Oxford University Press, London.

Huber, M. (1912). *Bull. de la Statistique générale de la France*, **1**, 402.

Morris, J. N., and Heady, J. A. (1953). *Brit. J. industr. Med.*, **10**, 245.

Registrar-General of England and Wales (1855). "14th Annual Report (1851)".

—— —— —— (1913). "74th Annual Report (1911)".

—— —— —— (1923). "Suppl. to 75th Annual Report. Mortality of Men in Certain Occupations in 1910, 1911, and 1912". Part IV.

—— —— —— (1927). "Decennial Supp. 1921. Occupational Mortality". Part II.

—— —— —— (1938). "Decennial Supp. 1931, Occupational Mortality" Part II.

—— —— —— (1954). "Decennial Supp. 1951, Occupational Mortality, Part I".

Stevenson, T. H. C. (1923). *Biometrika*, **15**, 382.

—— (1928). *J. roy. Statist. Soc.*, **91**, 207.

Stocks, P. (1938). *Ibid.*, **101**, 669.

Villermé, L. R. (1840). "Tableau de l'état physique et moral des ouvriers", 2 vols. Renouard, Paris.

Whitney, J. S. (1934). "Death Rates by Occupation, based on Data of the U.S. Census Bureau, 1930". National Tuberculosis Association, New York.

BRITISH JOURNAL OF INDUSTRIAL MEDICINE

Contents—July, 1954

Some Toxic Properties of Dimethylnitrosamine. *J. M. Barnes and P. N. Magee.*

A Report on 235 Cases of Erysipeloid in Aberdeen. *D. M. Proctor and I. M. Richardson.*

Raynaud's Phenomenon in Workers with Vibratory Tools. *R. P. Jepson.*

The Treatment of Complicated Pneumoconiosis with Isoniazid. *W. E. Miall, P. D. Oldham, and A. L. Cochrane.*

Silica and Collagen in the Lungs of Silicotic Rats Treated with Cortisone. *B. D. Stacy and E. J. King.*

The Development of Compensation for Occupational Diseases of the Lungs in Great Britain. *Andrew Meiklejohn.*

Tumours of the Urinary Bladder in Workmen Engaged in the Manufacture and Use of Certain Dyestuff Intermediates in the British Chemical Industry. Part II: Further Consideration of the Role of Aniline and the Manufacture of Auramine and Magenta (Fuchsine) as Possible Causative Agents. *R. A. M. Case and Joan T. Pearson.*

Thermal Conditions in Warships Refitting at H.M. Naval Base, Singapore. *G. Southwell-Sander.*

Miscellanea:

Some Personal Observations on Industrial Health in the United States of America. *Bryan Harvey.*

Second Conference of the British Occupational Hygiene Society. *R. J. Sherwood.*

Obituary:

Edward Provan Cathcart.

Raymond Hussey.

Book Reviews.

Abstracts.

Yearly Subscription (4 Numbers) £2 2s. *U.S.A.* $7.00.
Single Number 12s. 6d.

From the

Publishing Manager, B.M.A. House, Tavistock Square, London, W.C.1